TUBERCULOSIS OF BONE AND JOINT

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TUBERCULOSIS OF BONE AND JOINT

BY

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VISCOUNT NUFFIELD

BENEFACTOR OF ORTHOPAEDIC SURGERY
IN OXFORD
THROUGHOUT GREAT BRITAIN
AND IN THE DOMINIONS
THIS BOOK IS MOST GRATEFULLY
DEDICATED

PREFACE TO THE SECOND EDITION

At the present time tuberculosis in all its forms may be said to be at the cross road. It is only during the past few years that chemotherapeutic agents effective against the tubercle bacillus have become available and no doubt we are on the threshold of still greater discoveries. But it must never be forgotten that until a drug is available which will safely destroy all tubercle bacilli the old and well tried surgical principles laid down by Hugh Owen Thomas and Sir Robert Jones must always be the bedrock of our treatment of tuberculosis of bone and joint. That is our excuse for producing at this time a second edition of a book which deals not so much with latest inventions, new theories or experimental work, but rather is designed to act as a sound basis for treatment which has stood the test of time and on which may be superimposed future advances as they become proven.

In this second edition we have enlarged somewhat on the pathology, adding certain photomicrographs for which we are indebted to Dr. Robb Smith, Pathologist to the Radcliffe Infirmary. We are also indebted to Dr. F. H. Kemp, Radiologist to the Wingfield Morris Orthopaedic Hospital, for his contribution to the section on radiology.

Chemotherapy has been dealt with briefly and in a general way rather than in detail for each type of lesion, because we believe that it is far too early to lay down hard-and-fast rules for the administration of these drugs or to gain much from the results obtained to date. We have revised the Appendix, going into some detail of the use of splints and plaster, and we are indebted to the editor of the *Lancet* for permission to reproduce Figures (161, 162 *a* and *b*). In the remainder of the book we have in places rearranged the order of material, adding accounts of those procedures which we feel are sufficiently well tried to be found of lasting value. Lastly we have reviewed the illustrations, omitting some and adding others which may serve a more useful purpose.

We would also like to acknowledge the many others who have given us their help and advice but who are too numerous to mention here by name. And finally we would like to thank the Oxford University Press for their help and co-operation in presenting this second edition.

G. R. GIRDLESTONE
E. W. SOMERVILLE

Since the completion of this second edition I must, with great regret, record the death of G. R. Girdlestone, who with his great experience of tuberculosis of bones and joints over many years must always remain the real author of this book.

OXFORD
August 1951

E. W. SOMERVILLE

PREFACE TO THE FIRST EDITION

This book with all its imperfections comes at least from a background of great interest and much experience, for its author, after a fortunate and happy apprenticeship with Robert Jones and Sinclair Hunt, has spent twenty years at this work learning from success, from failure, and from his specialist colleagues in England and all over the world. Furthermore he owes not a little to his junior colleagues, the past and present staff of his own hospital, whose running criticism provides a bracing atmosphere in which authority withers and only true principles and reasonable practice can survive. From this practical training he has derived some understanding of the invading infection and human resistance, and some ability to find the best solution of each one of the infinite variety of individual problem. Surely the avoidance of rule and routine is the foundation of good treatment: a patient will be treated indifferently who is treated impersonally on standard lines. In skeletal tuberculosis many factors contribute to each clinical picture: we must group the cases for systematic teaching, but they are better regarded as individual problems in the wards; therefore we plan our treatment to suit the case, and alter the plan if the indications change, learning to wait for and recognize the right time for each new step.

I have tried to present clearly and with significance a balanced conception of the disease, with the bearing and time relations of infection and reaction, and to describe the various influences at work, favourable or the reverse, and how far and in what way they can be controlled. A complete grasp of all this is fundamental, but not nearly all that is demanded of us. When, for example, in the course of the morbid process joints are damaged or deformed the patient needs a combination of biologist, engineer, and surgical craftsman. Such indeed are the acquirements of every orthopaedic surgeon worth his salt, and he will serve best who has attained the fullest understanding and skill. Stimulated by Sir Arthur Keith[1] he will have studied the characteristic reactions of osteocyte and fibrocyte so that he may foresee and bend to his purpose the living response of the materials of his craft.

OXFORD
January 1940

G. R. GIRDLESTONE

[1] *Menders of the Maimed.* Oxford Medical Publications, 1919.

CONTENTS

CHAPTER I

GENERAL CONSIDERATIONS

THE NATURE OF THE DISEASE

Tuberculosis of a bone or joint is a metastatic focus, and its appearance is a proof that some pre-existing tuberculous lesion, known or unknown, is active and infecting the blood. This knowledge is necessary for a true assessment of the problem presented by each case, and should be a safeguard against the folly of attempting to cure a patient quickly by some operation—new or old. The treatment of skeletal tuberculosis is often difficult and some mistakes can be excused, but surely not that of forgetting or disregarding the existence of an active primary lesion! These hidden, silent foci are easily forgotten, yet it is after the arrest and apparent cure of the obvious lesion that they must most carefully be kept in mind, for only thus can sound and final healing be safely achieved. It is true that occasionally an articular focus may remain active for mechanical reasons long after the patient has regained health and general resistance, but only in such rare and exceptional cases can successful operative treatment of the skeletal lesion accomplish also the cure of the patient without more ado.

Infection

The bacilli gain entrance to the body through the alimentary tract in young children, or by inspiration of infected droplets at all ages, and rarely by traumatic implantation in the handling of infected carcasses.

Skeletal tuberculosis is due to infection by either human or bovine bacilli. These are similar in appearance but fortunately exhibit differences to culture and animal inoculation by which they can be distinguished. Occasionally bacilli are found which are not true to either type; it is natural to expect that these atypical bacilli would show characteristics suggestive of a transitional phase between bovine and human, representing bacilli originally bovine but tending toward the human type as the result of prolonged life with their human host. But apparently this is not the case.

Formerly the infection of young children by tuberculous milk was common; indeed, 85 per cent. of cases of skeletal tuberculosis under the age of 10 were due to bovine bacilli. Of late years, however, there has been a complete swing over so that the proportions are reversed. There is no indication of a change in the total number, and it seems that an increase of human infection has balanced the decrease in bovine. Human infection is more common on account of the lack of segregation of cases of open pulmonary tuberculosis necessitated by a shortage of hospital beds, while bovine infection has been largely diminished by widespread enforcement of pasteurization of milk in urban and semi-urban districts.

There is no clinical evidence that either type of bacilli is more virulent than the other The great variations experienced in the clinical course of the disease appear to be due entirely to variations in human resistance Tubercle bacilli seem to show a fairly constant virulence human resistance is widely variable and the variations are largely due to the influence of environment, good or bad The bacilli find their way quickly into a gland where they are

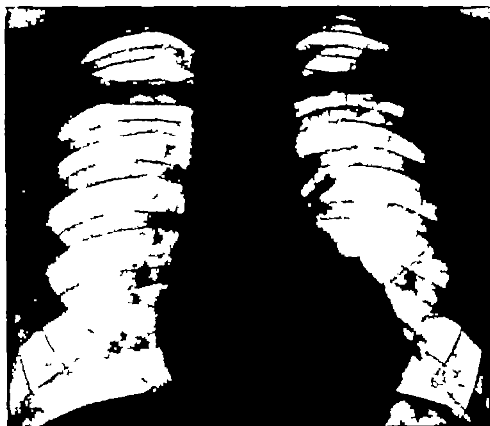


Fig 1 Lung-gland complex. X ray of chest showing what is frequently the initial tuberculous lesion, the lung-gland complex At the left apex is a typical early lesion from which can be seen inflamed lymphatics extending to an enlarged gland at the hilum.

held up but in about half the cases they establish themselves for a time at least in the lung forming in children what is called a primary lung-gland complex (Mann 1945) If the resistance is high the infection will be rapidly localized and slowly sealed off If it remains high this sealing will become sound On the other hand if the resistance is low the disease will progress for a time and so long as it remains low there is a risk of metastases or miliary tuberculosis. Once they have taken root their victim is suffering from tuberculosis and he and his advisors will find themselves committed to a long-drawn-out war of which the skeletal lesion when it appears is just an additional campaign

If however general and local treatment succeeds the disease will gradually lose the initiative. As resistance hardens the phase of healing begins and goes on, reaching in due time, if the patient is young, firm fibrosis or calcification. The duration of this process, of course, varies between individuals and age has a considerable bearing on it, but it may be said with some certainty that it rarely takes less than two years to complete the process. It must always be remembered that the healing of many lesions is incomplete for a long time even in children, and probably never quite safe and sound in adults in whom there is always a risk of recurrence in the old lesion or the development of a fresh one. This disaster can only be avoided by effective and long continued aftercare. In elderly people healing is seldom achieved, but often the active signs resolve leaving an appearance of quiescence which may be true and last for years, or merely serve to mask the stealthy advance of a deadly disease.

In children recently admitted to an orthopaedic hospital for skeletal tuberculosis a primary lung gland complex could be demonstrated by radiography (Fig. 1) in about [illegible] per cent of the cases (Mann, 194[illegible]), and of eighty-eight specimens in which typing was carried out 94 per cent were human. Fortunately in most of these cases, which were already under good general and local treatment, the pulmonary element proved evanescent. The appearance of a skeletal lesion may be the first obvious sign of the disease, for it is only in the neck that glands are readily seen or felt; furthermore deep-seated lymphatic tuberculosis is painless and so insidious that we neither know when it appears nor when it ends, and both are matters of vital importance. The tubercle bacilli in the lymph glands are attacking and destroying the very substance of the filter; the gland becomes choked with debris and cellular reaction so that the diseased gland is no longer capable of admitting lymph, filtering it and passing it on. The cellular reaction may in the end win and lead to healing with fibrosis or calcification, or it may fail with a breaking down of the gland (Figs. 2 and 3). Indeed we know that so long as lymphatic disease is active, debris containing tubercle bacilli is frequently passing from these glands into the blood-stream with a constant menace of infarction plus infection. The frequency of these showers probably varies with the activity of the disease. In animal experiments with active progressive disease, tubercle bacillaemia is almost constant, and in fatal human cases tubercles of different ages can be demonstrated post mortem. The frequency of bacillaemia in human tuberculosis as evidenced by positive blood cultures has been the subject of some controversy. Löwenstein[1] demonstrated a very high frequency, whereas Wilson[2] considers that positive cultures can be only obtained in 2 per cent of cases of non pulmonary tuberculosis. Infective embolism can happen anywhere; the issue depends partly on the arterial pattern in the part, but even more on the general health and vitality of the patient, which is our responsibility.

[1] Lowenstein, *Münch. Med. Wchnschr.* 1931, 78, 761.
[2] Wilson, *Med. R. Council Spec. Rep. Series*, 1933, no. 182.

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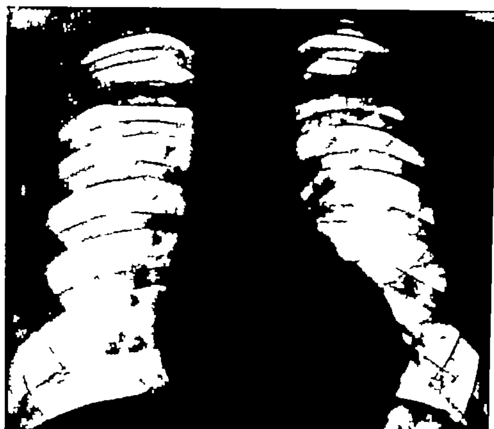


FIG 1 Lung-gland complex. X-ray of chest showing what is frequently the initial tuberculous lesion, the lung-gland complex At the left apex is a typical early lesion from which can be seen inflamed lymphatics extending to an enlarged gland at the hilum.

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A tuberculous focus may spread locally by direct infiltration through the tissues or along lymph channels and ducts The development of a lesion at a

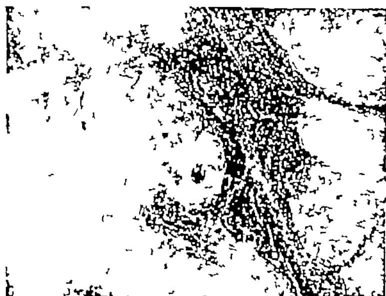


FIG 2. Tuberculosis of a lymph node. The disease is in an early stage showing typical giant cell system but no caseation (×65).



FIG 3 Tuberculosis of a lymph node A rather later stage in which early caseation can be seen (×65)

distance i e a metastatic lesion follows when particles of infected tuberculous debris enter the blood stream and are deposited by embolism Tuberculous emboli may block an arteriole or lodge in a capillary in vascular tissue

children to ensure really good conditions after his return home This means that everything possible must be done to maintain his health lest similar causes produce similar results The patient came into hospital because a deep-seated tuberculous lesion became active and bacillaemic under his old working and home conditions, thus producing the skeletal focus If we allow him to return to the same environment with the primary lesion still unhealed it is only logical that he should relapse for his vitality will return to its old level and his newly acquired resistance will be lost This is, unfortunately quite a common story We have in connexion with the Wingfield Morris Orthopaedic Hospital an organization of aftercare in association with the tuberculous service of the region designed to eliminate or at least to mini mize this risk But even so in a series of 300 patients who had been out of hospital for five years or more 15 cases had returned to hospital from local recurrence or died of tuberculosis Without good aftercare the figures are very much higher and where a hospital fails to maintain contact with its old patients it is only too likely that many patients will be accounted cured when in fact they are ill in another hospital or dead Statistics in tuberculosis are worthless unless they concern true end results ascertained *at least* five years after the patient s discharge from hospital

Recent advances in chemotherapy are discussed later but it is well to issue a warning here against the conclusion that chemotherapy can replace the standard treatment of skeletal tuberculosis Wide knowledge the wisdom of experience and the acquisition of skill in the operative and conservative treatment of these cases must remain the foundation of their successful treatment However effective chemical agents may be in dealing with tubercle bacilli within reach of the circulating fluids of the body there are many lying protected in the caseous or semi necrotic tissues of skeletal or lymphatic foci surgeon and drug together can do much more than surgeon or drug alone The surgeon can eradicate massive foci leaving the more accessible bacilli to the drug But major and inaccessible foci are likely to remain Given a true understanding of a disease which is often monarticular but very very seldom monofocal and a balanced judgement of the means to hand, there is every prospect of much quicker and better results *but there will be a heavy crop* of unnecessary tragedies if the well founded principles and proven practice of treatment and aftercare are disregarded

THE SKELETAL LESION

Tubercle bacilli are carried to the spot by the blood, probably with the debris of breaking-down lymph glands In children, the occurrence of various embolic lesions close to the joints or epiphyseal discs, whether tuberculous pyogenic or due to uninfected infarction is relatively common This is due to lack of arterial anastomosis in these regions, where small areas of bone lie beside or are surrounded by cartilage for the embolism of an end artery leads to ischaemia or complete infarction, and, when the embolus carries organisms the infarction immensely favours the infection So too can

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local resistance be reduced by a bruise associated with thrombosis and cellular infiltration

Devitalization general or local and a massive deposit or shower of bacilli are factors predisposing to the development of a local lesion Once they have obtained a foothold their continued advance is favoured by poor vitality of the patient and by any strain or movement imposed upon the infected parts



Fig. 4 Tuberculosis of bone showing a large mass of granulation tissue at the margin of which bone destruction is taking place (× 65).

by lack of immobilization The bacilli multiply and so far as the cells surrounding them are killed there are produced areas of necrosis and caseation (Fig 4) At the periphery infiltration goes on until constrictive reaction limit the advance Besides this direct spread of disease a collection of infected debris or pus may work its way out by infective penetration along the path of least resistance (Fig 5)

On the other hand a characteristic initial reaction of the tissues to the presence of tubercle bacilli is occurring The bacilli are surrounded by endothelial cells and lymphocytes, and with commonly a few giant cells forming a striking feature of the histology A focus consists not in a single tuberculous follicle but in the aggregation and coalescence of a great many such follicles (Fig 2) At the centre there is caseous material (Fig 3) and all round the focus cellular infiltration During the initial stages there are gaps

in the defence and bacilli spread along lymph spaces and are carried along lymphatics to the regional glands But before long the foci are completely surrounded by cellular infiltration, and if all goes well the resistance of the patient rises and the cells infiltrating the neighbourhood of the lesion now capable of surviving the local toxaemia succeed in building up a sound

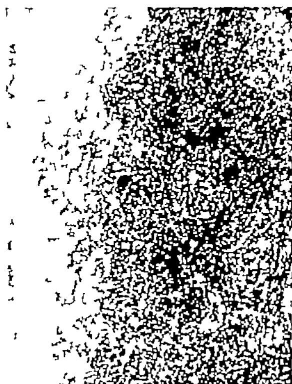


FIG 5 Part of the wall of a tuberculous abscess lined by caseous material deep to which is granulation tissue containing giant cell systems showing that active tuberculous infection is present (a) Inner wall of abscess (b) Deep granulation tissue.

fibrous capsule round the dead or dying bacilli. By this process they accomplish the arrest of the lesion In the course of time the fibrosis hardens and the healing becomes sound ultimately calcification may take place The process of healing calls for the constructive activity of granulation tissue in which fibroblasts have replaced the original reactionary fighting cells and formed a wall of scar tissue whether fibrous calcified or osseous Inside this wall are the agents and products of destruction outside it are normal cells carrying out their ordinary functions whether synovial cartilaginous or osseous. Furthermore we say that the healing is sound when the wall is solidly composed of adult cell elements The constructional units fibres or bone plates no longer show a disorderly arrangement or any infiltration with young unsettled cells but are now purposefully arranged to fulfil their permanent

function of resisting safely any forces to which they are likely to be subjected by the active use of the limb.

A tuberculous focus in bone or joint has the same general character as one elsewhere in the body, though it may be modified by its environment. The toxin of the bacilli has a most depressing action on osteogenesis, making the characteristic feature of a tuberculous lesion in bone decalcification and erosion without new bone formation. Thus a typical tuberculous lesion can be readily distinguished by radiography from one due to a pyogenic infection with its characteristic reactionary osteogenesis. It is also very rare to find in uncomplicated tuberculosis the sort of sequestra seen in sepsis. This is explained by the gradual decalcification of the bone and the slow poisoning of the cells, rather than the rapid extensive necrosis experienced in pyogenic infections.

Radiographs of tuberculous lesions sometimes show a cavity containing what appears to be a sequestrum, but exploration of such a lesion generally shows that the sequestrum is a mass of necrotic material partly calcified containing bone granules and perhaps a few very small sequestra. Occasionally a group of sequestra with or without the remains of an intervertebral disc may play a part in the production of Pott's paraplegia.

But it cannot be too strongly emphasized that all these remarks concern typical tuberculous lesions, typical results of invasion of the human by tubercle bacilli and his reactions, but we come across fairly wide variations.

Healing of the disease in bone occurs in the same way as elsewhere in the body. The lesion is first surrounded and later slowly replaced by fibrous tissue; the resulting scar may ultimately become calcified and even undergo ossification. Where new bone formation and sclerosis is seen instead of decalcification in a case otherwise apparently tuberculous, it should be remembered that tuberculosis may be associated with syphilis or a low-grade pyogenic infection, and that either combination would account for the unusual appearance.

An atrophic type commonly called 'caries sicca' is a condition usually found in the elderly, affecting the shoulder or spine. The disease is very chronic and insidious, the bone undergoing dry crumbling destruction without abscess formation.

Only the full understanding of the histology of healing gives the surgeon a well balanced clinical judgement in treatment and prognosis. Thus it can be seen that when a diarthrodial joint is infected with tuberculosis it is not safely and permanently cured unless it either moves freely or is soundly ankylosed. In children one may hope for a freely movable joint as the result of early, effective and long-continued conservative treatment. But in adults conservative treatment of weight bearing joints hardly ever leads to sound healing and never to recovery with free movement. The joints of the upper limb allow greater latitude because they are subject to less strain. Strong sound fibrous ankylosis is a late development, at the earliest *a year or more after the active disease is over.*

The toxins of tubercle bacilli have so depressing an effect upon bone cells that *osteogenesis seldom occurs except at a distance in space or time from an active tuberculous focus* say more than an inch away or more than a year after its quiescence This must be remembered by the surgeon whenever arthrodesis is required, for successful fusion depends on active osteogenesis and the cells will not build bone unless the design of the operation and the time of its performance are wisely chosen

POSSIBLE RELATION TO INJURY

Medico legal questions may arise as to the part played by injury in causing the lesion In this connexion the time relationship between an injury and the appearance of signs and symptoms is important A few years ago one of the authors was the subject of an accidental experiment in which the time data are reliable On 2.iii.26 while extracting some carious bone with a long gouge from the depths of a hip with severe pyogenic infection, he embedded the gouge deeply in the pulp and periosteum of his left middle finger The wound healed by first intention and with the danger of sepsis over and that of tuberculosis unsuspected, he gave the finger some hard work during the next few weeks. The area of the wound was a little tender but no more than expected *Ten weeks* after the implantation however the swelling and dis comfort were sufficient to make him feel that a diagnostic excision of tissue was advisable This was done (24 v 26) and a very long search resulted in the discovery of one or two tubercle bacilli He hoped that the focus had been removed, but unfortunately *seven weeks* later he felt something go while playing cricket he must have ruptured the granuloma for bacilli travelled up the lymphatics producing a large tender gland in the posterior triangle of his neck they also infected the tendon sheath It is to be noted that amputation of the finger (10 vii.26) and good home conditions have concluded the experiment!

The period of incubation may however vary considerably and there is evidence to suggest that the lesion develops more rapidly in patients with poor resistance Probably it would be fair to say that local injury can be excluded from causal relationship with the lesion unless it occurred more than a month and less than six months before the development of the *first symptoms* The nature and degree of the destructive changes give a general indication of the minimum time period since local infection

SITE OF INFECTION

1 Bone

The focus which arises in a bone as a result of the growth and development of a colony of tubercle bacilli may occupy various positions see Fig 6

There may have been a shower of tubercle bacilli over a considerable area and the vast majority will probably have been swept away into the lymph *stream or successfully encapsulated We are concerned with the survivors*

Favoured perhaps by infarction or bruising the bacilli deposited at one spot have been able to secure a hold and form a colony

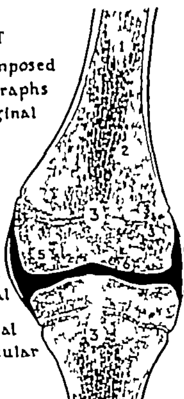


FIG 6 A composite diagram.

The lesion then may be

(1) diaphyseal (very rarely)
(2) metaphyseal
(3) juxta-epiphyseal
  (a) epiphyseal side
  (b) perforating
(4) juxta articular
(5) epiphyseal
(6) articular

Whilst this anatomical distribution is put forward as a necessary step toward a comprehensive grasp of joint tuberculosis the practical considerations are far simpler

Firstly there are the straightforward cases of tuberculosis of a bone nowhere near a joint e g the sternum or the shafts of long bones such as the metacarpals and metatarsals phalanges and more rarely the radius and ulna Still more rare is a lesion of the skull apart from the mastoid

Secondly there are the bony lesions which endanger a diarthrodial joint these will be considered with joint disease first in general then regionally

Thirdly in a class by itself there is spinal caries or Pott s disease with its most important complication Pott s paraplegia. This will be considered last of all

A bone focus nowhere near a joint and clearly neither irritating nor infecting it may cause indefinite pain and local tenderness or in a rib for example may produce an abscess without premonitory symptoms. Much more rarely a fairly widespread diaphyseal infection occurs

2 Joint

The infection of the joint may be *direct* in which case many minute follicles develop in and round the synovial membrane or just where the synovial



FIG 7 An early tuberculous focus in the subchondral bone Both cartilage and bone are showing signs of erosion (× 63).

membrane and the bone meet or *indirect* as when the infection reaches the joint after infiltration and erosion of bone With this second type which may be termed osseous the prognosis is relatively unfavourable For while a joint without radiographic evidence of bone erosion can recover movement a joint infected via an osseous focus is seldom soundly healed without full ankylosis

There is an intermediate group which might be termed juxta-articular here the original infection involves the junction of the synovial membrane and the bone Such cases are probably subject to the relatively favourable (synovial) prognosis with early and effective treatment but tend to become osseous and therefore unfavourable if the disease advances

(a) *Extra-articular*

This is a lesion fairly close to a joint with or without signs or symptoms of irritation or of infection. The distinction is difficult and the authors feel that in tuberculosis *irritation is a proof of infection*. It is their experience that *if the joint is irritated it is infected*, that in tuberculosis arthrism is arthritis. In the X-ray film the lesion may appear truly extra-articular and the joint normal, but in cases where definite symptoms and signs of arthritis are present the result of erasion of the focus by an extra-articular route is



Fig. 8. Synovial tuberculosis of the knee joint showing sub-synovial giant cell systems and fibrinous projections of the type which may become free as so-called melon-seed bodies (× 63).

almost always disappointing. Before very long radiographs begin to show articular erosion. The lag between infective invasion and visible erosion is misleading; in reality the bacilli invade and infect the bone spaces some weeks before they break up the bone structure. Disuse atrophy is widespread and gives no indication of the limits of infection. In such cases the authors agree with Calvé that the first step is prompt conservative general and local treatment. The progress of the condition can be seen with increasing clarity in a series of radiographs.

Occasionally genuine extra-articular foci are discovered when skiagrams have been taken because of pain of endosteal and not arthritic origin. Here erasion of the focus by a safe route is indicated.

(b) *Articular*

1. The synovial membranes may be infected from foci originally osseous (Figs. 7 and 8) which have worked through into a joint. This group, the largest, is unfortunately the most destructive of the joint.

2 The infection may be purely synovial and perisynovial (Fig 8) and if there are bone lesions they are minute and of the juxta articular type i e situated round the synovial edge and not involving any articulating part of the articular cartilage In children this is a relatively hopeful group for there is fair prospect of full restoration of function The synovia become thickened,

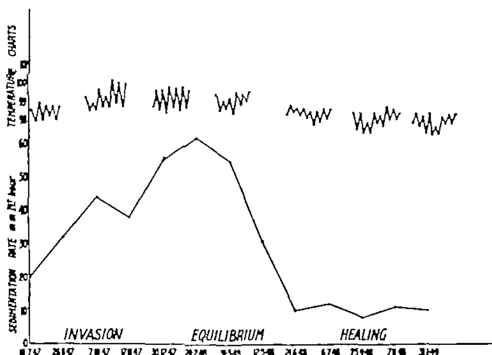


Fig 9 Case of closed tuberculosis of the hip in a boy 12 years of age.

Progress of disease illustrated by representative temperature charts and blood sedimentation rate over a period of eighteen months.

The disease can be divided into three stages.

1 Stage of invasion with pyrexia and rising sedimentation rate.
2 State of equilibrium when resistance and infection are about equal.
3 Stage of healing with fall in the sedimentation rate and temperature normal.

inflamed and rather gelatinous, in the course of time they are progressively destroyed and replaced by granulation tissue Hyaline cartilage is itself very resistant but subchondral erosion leads to its necrosis

For a series of end results in the knee refer to Tables 19 20 and 21 22 pp 201 and 224 225

Fig 9 illustrates the progress and phases of a fairly typical case of tuberculosis of the hip

COMPLICATIONS

In our work for skeletal tuberculosis we must be constantly on the watch for the many pitfalls and difficulties which may arise in the course of the disease and its aftermath Local complications such as abscess sinus, and secondary infection are dealt with elsewhere but there are other more

CHAPTER II

DIAGNOSIS

History

The patient's history will often help diagnosis Attention should be directed to the story of the onset, the duration of symptoms any loss of weight or energy the occurrence of night cries, and the character of the pain if any The family history may reveal contact between the patient and an open case of tuberculosis. A young child with tuberculosis and without such contact will probably be a consumer of raw milk

It is characteristic of tuberculosis that the symptom which first insinuates itself upon the patient's attention, or the parents notice does so very gradually The patient very seldom associates the beginning of his trouble with any particular day if for instance he says it began on a Tuesday the condition is probably not tuberculous!

Another very helpful point may be the relationship of the onset with an injury If the patient or parent tells you that he or his child has fallen and bruised his knee six to eight weeks ago and that ever since then it has been painful and troublesome the evidence for what it is worth is against tuberculosis But not so if the injury took place two or three months before and there has been a completely quiescent period of six or eight weeks between the injury and the first symptom

Generally the first thing noticed by the patient or parent is an interference with function and some swelling rather than pain Indeed pain and tenderness are slight at first the characteristic features being limitation of the full range of movement and a swollen warm, and somewhat tender joint, with the enlargement due to swollen synovial membrane rather than to fluid.

The inquiry may have revealed

1 The likelihood of human infection.
2 Previous manifestations of tuberculosis
3 Some loss of health and vigour ,
4 A history of an injury from six to twelve weeks previously with a normal joint during most of the interval.

CLINICAL EXAMINATION

Observe closely how the patient stands walks sits or lies and the position and movement of the joint in use and in repose Loss of function comes earlier than pain and a certain caution in movement will often be found significant

The presence of swelling of a joint without redness of the skin or much fluid in the joint with little tenderness and slight increase in warmth only forms a clinical picture strongly suggestive of tuberculosis After making

these observations the examiner should try very gentle passive movements. Nothing is to be gained by attempts to force movement and movements under anaesthesia are to be condemned if tuberculosis is suspected because the anaesthetic eliminates the protective muscular spasm. One may get a little information but at the risk of doing a good deal of harm.

The degree of pain on movement varies considerably. If the joint has been put at rest for some days there may be deceptively little discomfort when the surgeon handles it gently. But as a rule movement is much limited by muscular spasm, e.g. in the hip the pelvis moves with the limb. The characteristic sign of inflammation of a joint is this lack of movement or limitation *by muscular resistance* of movements *in all directions*.

The position of the joint should be carefully noted, for at an early stage of inflammation *a joint will often be held in a characteristic position, that which* most relieves the pain due to its distension by fluid. Later, when the joint is completely disorganized, the deformity will depend on habitual posture, on gravity, and on the pull of the most powerful muscles. The position of the *bony points should then be noted and the limb measured* to detect any subluxation or shortening. In examining the legs care must be taken to see that the pelvis is horizontal before measurements are taken. Muscular wasting is often obvious but nevertheless comparable circumferential measurements should be taken.

On admission the patient is again thoroughly examined and X rays are taken. The affected part is put at rest by suitable splintage and if the diagnosis is in doubt further tests are carried out.

In children the Mantoux intradermal test is a valuable procedure in that a negative result will count against tuberculosis, but it is only in young children that a positive result can be considered of any particular value. The test should be tried with 1 : 1,000 dilution and if this is negative repeated with 1 : 100 dilution.

In both children and adults it may be thought advisable to carry out tests for syphilis and in adults for gonococcal infection, but positive results in either case do not eliminate the possibility of tuberculosis.

If there is an abscess or fluid in the joint it should be aspirated and, if neither cocci nor bacilli can be discovered, the fluid centrifuged and a guinea pig inoculated.[1]

If there is no positive evidence of tuberculosis septic foci should be searched for and eliminated, e.g. in a child a pair of unhealthy tonsils may be found and in due time enucleated. If the diagnosis is still uncertain, children are treated continuously on a provisional diagnosis; the continuity is a matter of principle because most of the symptoms subside deceptively soon after immobilization has been started. The alteration to a definite diagnosis of

[1] Accuracy of Guinea-pig Inoculation in cases of Synovial Fluid from Tuberculous Knees. *Smith, J.B. & J.S.* 13, 740. (Out of 37 cases of chronic arthritis of the knee inoculation of the fluid into a guinea pig was negative in 3..., and of these 8 were proved subsequently to be tuberculous, i.e. negative results were ultimately proved inaccurate in 25 per cent. of cases.)

tuberculosis commonly depends on an unfavourable response to careful tests or on changes seen in a series of radiographs

In adults a relatively quick and definite diagnosis is advantageous and to this end diagnostic operation on joint or regional gland may be indicated.

Radiography

Just as the tuberculous infection of a part is insidious in the sense that it does not arrest the attention of the patient so too its action on the bone is unprovocative of an osteogenetic reaction A pyogenic invasion of a bone makes its presence felt within a few hours and in a few days there is bone destruction On the other hand bone may be infected and its spaces infiltrated with tubercle bacilli without any striking clinical or radiographic changes For weeks the X ray signs are imperceptible infiltration and later decalcification go on unseen and enable the disease to get a long start before the diagnosis can be made by radiology

Radiographic findings vary with the severity of the infection the reaction of the individual and the stage of the disease Clinical symptoms sometimes appear before any radiographic signs can be detected there is a lag between the infection of the bone and the occurrence of sufficient decalcification to appear in a radiogram particularly is this so when small foci are developing in a deep-seated bone Post-mortem findings have shown that a bone which has appeared normal in the X ray film may be extensively infiltrated with tuberculous infection Indeed it has been demonstrated that a third of the depth of the structure of a bone must be destroyed before any changes in the X ray appearances are likely to be detected Now it must be remembered that decalcification results not from the direct effect of the infection, not from a solution of the bone structure by some excretion of the bacilli but from a secondary effect on the function of the osteocytes However the earliest visible change is rarefaction A focus first appears as an ill-defined area of relative rarefaction later the bone in the central area may disappear or there may be left in the centre a shadow representing the bone which has not been dissolved because the bone cells have been killed this is more a cluster of residual bone debris than a clean-cut sequestrum The periphery of the focus generally appears indefinite but around it there may form a zone of increased density though this zone is usually less dense than that seen with pyogenic infection When a tuberculous sequestrum is seen as a result no doubt of an infarction by a tuberculous embolus it throws a coke-like shadow with ill-defined shape and structure these sequestra bear little resemblance to those of acute osteomyelitis Occasionally radiographic signs of ischaemia from embolism may appear before the evidence of tuberculous infection thus the early picture may be one of osteochondritis dissecans or one of the osteochondroses and only later will the temporary hyper-calcification dissolve into the decalcification of tuberculosis (see Figs 24–26) Thus the radiographic appearance of Köhler s disease or Scheuermann s disease may precede the ultimate tell tale rarefaction.

Where the infection of the synovial structures precedes that of the bone X ray appearances may be non committal for a long time decalcification of both bone and joint will indeed occur, but it may be difficult to distinguish the rarefaction of disuse plus disease from that due to disuse alone Sometimes synovial disease gradually erodes the articular surfaces leading to a false appearance of expansion of the articular space This is seen typically in the hip and elbow more rarely elsewhere In other cases of synovial infection the immediate surfaces of the joint are spared with erosion of the lateral aspect of the condyles In this chronic form tuberculosis in bone may mimic other conditions There is one unusual form in which the sub-articular bone shows multiple cyst like areas surrounded by sclerosis The joint surfaces may show some deformity and there may be marginal lipping This picture may easily be mistaken for that of osteoarthritis We must emphasize that there are certain phases sometimes early sometimes late in tuberculous lesions during which the radiographic picture may be indistinguishable from those due to many other causes these include the effects of injury of pyogenic inflammation various forms of non-specific arthritis haemophilia secondary neoplasms and endotheliomata arising from the synovial membrane

Just as there is a lag in the X ray evidence of the early development of the disease so too is there a lag in the radiographic signs of healing The organization of granuloma into sound fibrous tissue or the encapsulation of residual debris are themselves processes invisible to the radiologist often they can be inferred by the advancing reconstitution of the surrounding bone but conclusive evidence will only appear with the ossification or calcification of granuloma or the calcification of debris.

Atrophy due to prolonged disease and disuse affects not only the internal structure of a bone but the size strength and shape of all the bones of the part The circumference of the shaft is diminished so too is the thickness of the cortex and occasionally premature closure of the growth-discs accounts for shortening On the other hand persistent grumbling infection near the growth discs may result in over-growth

The sequence of the changes which have been outlined is slow and except in the earliest stages when the first X ray signs are to be expected there is little point in repeating X ray examination at intervals of less than three months

Diagnosis may often be accelerated by the demonstration of tuberculous lesions elsewhere The initial X ray examination should always include the chest and this should be repeated at intervals Stereoscopic radiography and tomography may be of value under exceptional circumstances X rays too will contribute to the diagnosis of renal complications and where renal tuberculosis is suspected excretion urography is required

In skeletal tuberculosis special care must be taken of the patient in the X ray room in order that his immobilization may be accurately maintained this means that the staff of the X ray department should work in close

liaison with Residents and Ward Sisters Later on, when the disease is quiescent the patient may be moved a little more freely in order to obtain a more detailed X ray picture

PROVISIONAL DIAGNOSIS THE OBSERVATION JOINT

Since the nature of the disease is such that an early definite diagnosis is impossible we must put up with *a provisional diagnosis and act on it as quickly and stringently as if it were definite*

The advantage of making a provisional diagnosis and taking early decisive action is very great and may well mean all the difference between perfect *recovery with free mobility and a stiff joint in a wasted limb In former times* the diagnosis was not made until after symptomatic treatment of the early synovitis had failed and the signs of tuberculosis had become unmistakable[1]

Radiological evidence of decalcification *and erosion were regarded as* standard features of articular tuberculosis and unless these appeared, or laboratory proof was forthcoming the diagnosis of tuberculosis was quite properly regarded as dubious. Our modern attitude is that a provisional (admittedly dubious) diagnosis is fully justified if it improves the child s chances of regaining the normal use of his joint There is so great a contrast between such a result and the stiff joint and shortened limb of a child who has been treated expectantly by patchwork periods of rest and expectancy until radiographs have made the diagnosis clear and admission to an open air special hospital has at last seemed warranted! This does not happen if the cases are admitted immediately to an orthopaedic hospital for observation. Ready co-operation between doctors and hospitals and between general and orthopaedic hospitals will bring this about and give the patients the best prospect of recovery with normal function, or at least with minimum damage

In the synovial group then X rays give no specific information. Unfortunately the early signs and symptoms are so slight and unalarming that it is hard to persuade oneself and still harder to convince the patient and his parents of the necessity for his admission to hospital One is tempted to hesitate to try a month or two in plaster and so on. Such patchwork may cure the transient arthritis but it ruins the chances of a tuberculous joint and at this stage one cannot tell which is which and must therefore play for safety To hesitate is to be lost for after a month or two of immobilization the joint appears deceptively normal This disappearance of signs and symptoms is indeed a standard trap in the diagnosis and treatment of tuberculosis of bone and joint It is so tempting to treat the signs and symptoms and to remit treatment when they disappear so deceptively And synovial tuberculosis readily enters into this game of cat and mouse Indeed, the disappearance of all signs of inflammation after a few weeks of immobilization should be regarded as part of the normal clinical picture of synovial tuberculosis Thomas offered us our safeguard—the *secondary diagnosis* see p 30

The sedimentation rate

A single examination of the sedimentation rate is of little value in the diagnosis of tuberculosis though an exceptionally high reading suggests severe toxaemia But the test is non specific and is affected by many factors On the other hand this can be of considerable value when taken at regular intervals throughout the course of disease as an indication of the clinical progress of the patient (Fig 9)

But occasionally where there has been a high reading during the active phase say about 70 mm in the hour and after progressive clinical improvement has been associated with progressive diminution of the figure there may be a check in the fall at about 20 or 30 mm despite the continuation of favourable progress In the authors experience this need not be regarded as indicating persistence of active disease A figure of 20 or 30 mm may remain for years after every other sign and symptom of disease has disappeared

Diagnostic operation by arthrotomy or removal of an enlarged regional gland

The indications for a diagnostic arthrotomy have not been settled therefore a few years ago one of the authors sent a number of his colleagues a questionnaire Do you do a diagnostic arthrotomy? If so what is your procedure? That the indications had not yet been agreed on was clear from the answers Often or always 13 No or never 15 Rarely Occasionally Only in selected cases 13 But the answers have enabled him to outline the indications and contra-indications To begin with it should be understood that diagnostic arthrotomy is not without danger to the patient and may misdirect the diagnosis! For unfortunately a diagnostic arthrotomy is by no means always decisive and purely negative findings must be regarded as provisional since the bacteriologist or guinea pig returns a negative report if the *particular material supplied* is not *infected* by tubercle bacilli. For the *characteristic histology is only seen when tubercle bacilli are themselves present (though perhaps not easily seen) in the microscopic field* This is analogous to the radiological position And purely negative reports from the histologist bacteriologist and guinea pig ought to be classed with negative reports from *the radiologist*

Then again both Osgood and Ober[1] report that the wound may break down and give rise to prolonged trouble It is clear that there is danger of tuberculous infiltration of the wound track outwards followed by pyogenic infection inwards The former is a slow affair and can always be prevented by arthrodesis within a week or two of the diagnostic arthrotomy It must be true to say that diagnostic arthrotomy is *safe if a positive diagnosis of tuberculosis will be quickly followed by fusion, and dangerous only when conservative treatment will be continued despite a positive diagnosis*

The authors suggest that in young children a clinical diagnosis carefully

[1] Personal communications.

tested and reviewed, is all that is needed arthrotomy is contra indicated for it is risky and unnecessary In children persistence of a chronic decalcifying arthritis is sufficient for all practical purposes

It has been pointed out by Seddon[1] that in the early stages of a bone o joint lesion one or more of the regional glands may be infected and enlarge and that the excision and examination of such a gland by microscopy o guinea pig inoculation will give positive information without the need fo operative exposure of the joint

The lymphatics of the hip drain into the iliac glands and for biopsy th largest of these glands is removed through a muscle-splitting incision jus above Poupart s ligament The lymphatics of the knee run mainly into th deep inguinal glands but occasionally some of the superficial glands may b involved It is best therefore to remove both a superficial and a deep glan for examination It may be assumed that most of the lymphatics from th ankle eventually pass into the deep inguinal glands But any enlarged gland popliteal or inguinal should be chosen

In the upper limb the glands in the axilla are numerous, and rather widespread here again, as in the inguinal and iliac regions it is possible to remove a normal gland and to leave another showing tuberculous infiltration un noticed. It is probably wise only to remove glands in the upper limb if they are palpably enlarged.

At the operation an enlarged gland is removed and subsequently cut in two one half is put in formol saline for section the other in sterile normal saline for guinea pig inoculation The results of this procedure have been investigated by Scott and Arden (1947) They reviewed the pathological findings in conjunction with the subsequent course of the disease in twenty nine hips and sixty knees also in a smaller number of other joints which were too few to give a definite conclusion. But with regard to the hip and knee they were satisfied that a positive gland biopsy was of value but that a negative result should not be regarded as disproving tuberculosis.

Biopsy from gland or joint is indicated when a definite diagnosis cannot be reached by other means and there are good reasons for avoiding further delay

In children exact diagnosis is rarely urgent and as has already been stated arthrotomy is only indicated when the patient is ready in stage and in age for fusion On the other hand an enlarged regional gland can be safely removed at an early stage and is then more likely to give positive information than later on

Diagnosis by chemotherapy

Occasionally the diagnosis can be cleared up by chemotherapy Sometimes an intensive course of penicillin will lead to the rapid resolution of signs and symptoms and we know that penicillin is without effect upon tuberculosis or it may be that streptomycin given in full doses for three or four weeks will

[1] Seddon, H J *British Medical Journal*, 21 Jan., 1939 p 105.

lead to the disappearance of the signs and symptoms much more quickly than could occur in tuberculosis. Case W. W. is an extremely good instance. Unfortunately the fluid removed from the hip gave a negative culture and the discharge from the ear was not investigated.



FIG. 10. Four pictures. Case W. W.
(a) Low-grade infection of the hip 4.1. 49.

1. 1. 49. Case W. W., a boy aged 5 with pain in the right knee for four weeks. Signs of arthritis of the hip (Fig. 10); the Mantoux test was strongly positive (two months later it was negative) and the E.S.R. was 11 mm. Provisional diagnosis of tuberculosis was made and the hip immobilized in a plaster spica first and later on a frame.

8. 49. Developed acute otitis media.

19. 49. Pyrexial and complaining of headache.

Meningitis diagnosed. On lumbar puncture the c.s.f. was slightly turbid with no increase in pressure. Analysis showed: protein 82 mgm. per cent., sugar 5 mgm. per cent., cells 611, mainly lymphocytes. Culture was sterile. On the following day his condition was unchanged but lumbar puncture showed an increase in the number of cells which were now mainly polymorphs.

It was considered that the meningitis was probably pyogenic and the patient was treated with

Streptomycin 5 000 units intrathecally and 500,000 units intramuscularly each day
Penicillin 100 000 units four hourly and sulphadiazine 0·75 grammes four hourly
Improvement was rapid, the streptomycin and sulphadiazine were discontinued on 27 vi.49 and the penicillin on 28 vi.49 by which time the C.S.F showed 155 cells, 67 per cent. neutrophils with 46 mgm. protein. The otitis media had also cleared up



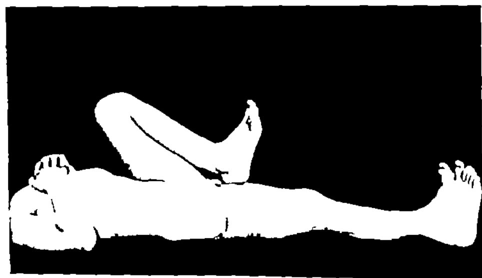
(b)

Fig. 10 (b) Same case after treatment (see text) 22.ix.49

During this time the hip was treated by traction only immobilisation being impossible.
2.viii.49 Readmitted to Wingfield Hospital. No clinical abnormality could be found in the hip, there being a free painless range of movement equal to the normal side. Figs. 10a b c d X ray films showed a steady improvement in osteogenesis without loss of articular outlines.

Discussion From this unusual case-history it would appear that the otitis media hip disease and meningitis were closely linked and due to the same infecting organism as all three conditions improved simultaneously And the resolution under chemotherapy was so rapid that the original diagnosis of tuberculosis had to be abandoned

)



(*d*)

Fig. 10 ( ) and (*d*) Showing full range of movement 22.ix.49

When an arthrotomy is done attention should be paid to the following points

(a) Ample incision into the joint for inspection of *synovial* membrane and articular surfaces or if the signs are localized, a smaller incision in that region. The surfaces of the wound should be carefully protected from contamination by the material from the joint

(b) Discovery of the most diseased part and removal of a generous sample of this for histological examination

(c) It is well to ask the pathologist also to be generous in his supply of material to each guinea pig for the infection may be slight and scattered.

Comparison of laboratory methods

Professor A. D Gardner a bacteriologist who has made a special study of this subject has furnished the following table dealing with examination of portions of synovial membrane removed at arthrotomy in 18 cases which proved tuberculous.

TABLE 1

	CASES	PER CENT
Positive histologically	17	94
One case was negative histologically and by guinea pig but proved by finding T.B in smear		
Positive by guinea pig test	13	72
Positive histologically } Negative by guinea pig } Negative histologically } Positive by guinea pig }	4	22

N.B —For histology from one to four selected blocks of tissue were prepared, one if the tissue looked obviously tuberculous, several if it appeared doubtful.

Thus Professor Gardner's experiences show that a pathologist experienced in tuberculous material, who is prepared to take time and trouble is at least as good as a guinea pig in finding the bacilli in fluid and a diagnosis from tissue A portion of tissue sufficiently infected to give a guinea pig tuberculosis will show tubercle bacilli or be histologically characteristic of tuberculosis.

CHAPTER III

THE GENERAL TREATMENT OF THE DISEASE

PROPHYLAXIS

MUCH can be achieved in two fields first by an organized effort towards the elimination of all sources of tuberculous infection human and bovine Open tuberculosis of the cow s udder and the human lung are sources of living tubercle bacilli Both these sources are dangerous but of the two the latter is much the greater The elimination of tuberculosis from dairy herds is most desirable but *tuberculosis in cattle is so prevalent in some countries* that rapid realization of this ideal is altogether impracticable Fortunately it has been proved that infection from tuberculous milk ceases to be a danger wherever efficient pasteurization is in force On the other hand close association with a careless patient suffering from open pulmonary tuberculosis is likely to lead to repeated heavy and therefore most dangerous droplet infection That is the reason for segregation and where segregation cannot be maintained for the most careful education of the patient for the safety of his neighbours

A second public duty is to maintain the health of the community by the exclusion of all avoidable devitalizing factors such as poverty overcrowding bad housing overwork, and dangerous working conditions An ample and well balanced diet is of special value

The action required by these considerations is social service a duty of governments and local authorities—immensely important to the control of tuberculosis but outside the scope of this book.

We have as yet no sure means of developing the specific active immunity of our patients though the value of vaccination with bacilli of attenuated virulence *is still being explored. General treatment comprises the skilled use* over a long enough period of four natural remedies rest food, the sun and the open-air

FOOD

Food must be adequate but no more well cooked attractive and appropriate to the weather Our patients do not need fattening unless they are too thin and should be little above their normal weight The diet should be simple well balanced and pleasantly served indeed the probationer may have to exercise a good deal of tact and charm in feeding the frailer sort of child.

Our patients are very much exposed to the weather and when it is cold require more food and especially more fat In hot weather on the other hand, their meat fat bread puddings and suchlike should be reduced but they should have plenty of fresh fruit vegetables and be persuaded to drink

extra water mostly between meals as a precaution against renal calculus (see p 33)

THE ACTION OF SUN AND WIND

In treating skeletal tuberculosis we aim at giving our patients physical rest and metabolic stimulation and it is to the open-air the sun and the wind that we look for the latter

It is the authors opinion that the main virtue of so-called heliotherapy lies in the exposure of the patient to the varying stimulus of warmth and cold wind and calm and all changes of the weather

It is this part of the treatment that can only be carried out in open air country hospitals and it was in 1910 that one of the authors first came across such a hospital in Shropshire. During his time in the wards of a London hospital, first as a student then as a House Surgeon Pott s disease and hip disease had meant deformity septic complications and in the end the slow miserable progress of lardaceous disease In contrast to this the work of Sir Robert Jones in open-air hospitals at Baschurch in Shropshire and at Heswall in Cheshire seemed miraculous The children with tuberculous spines hips and knees looked perfectly fit and at Heswall they had not lost a patient from lardaceous disease for two years All this was accomplished without direct exposure of their bodies to the sun

The action of the sun on the body

1 *Its photochemical action* (a) Synthesis of vitamin D from ergosterol this is absorbed and is helpful to patients with vitamin D deficiency Vita min D can be administered from the dispensary

(b) Irritation advancing to destruction of very superficial living tissues the absorption of the products, within small limits and in certain cases, may be beneficial But the danger of overdose is definite and *to febrile patients any dose is an overdose therefore their bodies should never be exposed to sun light* Gross overdose in the ordinary patient is demonstrated by a rise in evening temperature

It is only in the spring and summer that an overdose of light need be feared in temperate climates and at ordinary altitudes and Rollier s table designed for the Alpine sunlight is needlessly slow for our English sun The authors fully agree with Rollier that several short exposures are better than one long one

2 *Its heat* A warm sun and cool wind combined have great virtues The sun keeps the patient warm whilst the moving air cools and stimulates the skin The effect is rather that of a long-continued relatively genial contrast bath The metabolism of the skin itself and of the muscles and viscera (liver &c) through reflex association is stimulated. Too much heat is as bad as too much ultra violet light for its relaxing and devitalizing effect is the very opposite of what we want In particular *great care should be taken to avoid any warming up of the local lesion* for that is most harmful This

danger is rather generally overlooked e.g. a plaster containing a tuberculous ankle is repeatedly baked in the sun if an abscess follows the innocent plaster bears the blame!

In a hot summer it is only too easy to do more harm than good by the application of the sun's light and heat to the body and even without direct exposure it may be difficult to keep the patients cool enough in or out of doors One way and another the summer sun can easily do more harm than good so much so that in hospitals which are ill designed or ill informed the patients do better in winter than in summer Perhaps the most important clinical point in the design of a ward for tuberculous cases concerns its capacity to keep cool in very hot weather

3 *Its psychological effect* Sunshine is cheering and stimulating but only if the patients are given adequate alternating periods in deep shade The sun should not be allowed to shine in the patients eyes

4 Exposure to sun and wind dehydrate the body (see p 33)

The wind

This is probably the most valuable component of heliotherapy The wind cools the skin by convection and stimulates it by its ever varying impact The combination of cool moving air with warm sunshine is pleasant and like a contrast bath, promotes active hyperaemia of the skin Leonard Hill reported that in Montana the heat production of the resting subject was put up to a notable degree higher than was the case with the children at Alton in summer but not higher than the latter in winter [1]

The effect of the wind on the body is not wholly the result of cooling for there is also the reflex stimulation of the viscera from the skin.

The air bath

Heliotherapy can be carried out without visible sunshine As much as possible of the body is exposed to the open air for a period which if it is to be the best must be judged on each single occasion for each individual Here again is an opportunity for the probationer to contribute personally to the success of treatment

The authors have great faith in the value of air baths all through the year and they think it probable that the ordinary English weather applied to the skin in well regulated doses will be found as effective in the treatment of tuberculosis of bones and joints as that of other climates and more helpful than indoor artificial sun

Through the winter the patient should have three or four air baths a day In very cold weather he should have just a few seconds exposure of the body to a touch of keen wind never long enough to cause a harmful chill The air bath should give an enjoyable cooling stimulus and be followed by a reactionary glow

Our ward sisters should be *taught directed and frequently reminded to use*

[1] Hill, Leonard *Journal of Tuberculosis* April 1922.

the wind and open air up to the optimum in the winter and warned often and forcibly against the danger of the sun in summer except in the early morning and in the evening

CHEMOTHERAPY

Streptomycin seems likely to prove of immense value in the treatment of skeletal tuberculosis and its septic complications Indeed the position seems closely analogous to that of penicillin versus the gram positive cocci though it would be foolish to expect such quick results Not only is the tubercle bacilli protected by its waxy coat but the very nature of the tuberculous granuloma makes it unlikely that any blood borne drug can reach all the bacilli for many of them lie in the avascular caseous centres of the tubercles and in the ischaemic semi-caseous and fibrotic material around. The efficacy of both these agents depends upon their access to the bacteria Where the bacteria are in a vascular area the drugs are effective if given in sufficient dosage and for a sufficient period. But where the bacteria exist in large un drained abscesses or amongst necrotic tissues the drug cannot get at them In such cases surgery and chemotherapy can succeed by a well planned com bined operation.

It is furthermore unfortunate that streptomycin differs from penicillin in being toxic to human tissues affecting particularly the kidneys and the eighth cranial nerve Finally it seems that tubercle bacilli exposed to ineffectual dosage quickly become resistant to the drug The dose reaching the bacilli is ineffectual if the daily administration is too small or where the bacilli are relatively out of its reach

It is in caseous granulomata or amongst necrotic tissues that high resistance develops But the thorough drainage of abscesses, and the excision or erasion of caseous and seminecrotic tissues leave the remaining bacilli exposed to the streptomycin. Thus the surgeon helps chemotherapy and we may con fidently hope that chemotherapy will in its turn help the surgeon by making operation on an active lesion relatively safe from risks of dissemination of the disease or the secondary development of sinuses. For the blood-stream and the tissues in intimate association with it are protected by an adequate concentration of this powerful bacteriostatic agent Thus for example (see Case J.A p 32) a juxta-articular focus can be excised or curetted not only without the fear of promoting the *infection of the joint but with confidence* that should any such infection occur it will not become established It is said (Harley Stevens) that some of the toxic effects particularly the various forms of dermatitis are due to vitamin deficiency brought about by an altera tion of the bacteriology of the large intestine which interferes with the synthesis this has been confirmed by Cairns and Smith in their work on meningitis (personal communication)

Dosage

The dosage for adults is generally at least 1 gm a day and seldom more than 2 gms Cairns and Smith of Oxford in dealing with tuberculous menin

gitis give adults 2 gms a day and are prepared to go on for a minimum of six months and do in fact continue up to a year in some cases For infants they give 0 2 gms per kilo body-weight It works out that young children get about ½ gm children of 6 or thereabouts get about 1 gm and adults 2 gms This intensive and prolonged medication is supplemented by the administration of the principle vitamins of which the B complex is thought the most important Even so it is not without its drawbacks It is necessitated by the stubborn resistance of the infection which is proved not only by the appearance of tubercle bacilli in films quite late on in the treatment but also by a liability to early recrudescence soon after the remission of treatment The eighth cranial nerve is damaged in almost all their cases with loss of the vestibular reaction and also in a much smaller proportion deafness But they are convinced that it is justified in the treatment of so fatal a disease as tuberculous meningitis and in the series of seventy unselected cases with which they have dealt life has been saved in about 50 per cent This is very remarkable when one remembers that some of the cases have been complicated with miliary tubercles or systemic tuberculous disease

In addition to the intramuscular injections of 2 gms for a minimum of two months they also give daily intrathecal injections of 0·1 gm streptomycin in saline and go on for eight weeks after the last appearance of tubercle bacilli in the films continuing even longer than this if the clinical condition is not fully satisfactory This is not all for in some cases after four weeks intermission they go on to a course of twenty injections given every other day then another month s intermission after which decision is made as to the necessity for further chemotherapy on a general estimate of progress This is reached by a consideration of the patient s weight which should be gaining C.S.F cells and protein which should be dropping the temperature which should be steady and the E.S R which should have fallen (though this may still be above normal)

In reviewing the dosage then we have in the treatment of tuberculous meningitis an instance of a disease which was almost invariably fatal and in which it is justifiable to push the dosage to the extreme limits of safety and beyond, in order to save life as often as possible In skeletal tuberculosis on the other hand the situation is quite different In the large majority of cases the outlook is favourable with the standard general and local treatment which has long been understood and is described in this book It is therefore wise to reserve chemotherapy for cases in which it is likely to be effective and in these cases to give it with due regard to the limits of safety both in dosage and period At the same time it is clear that it is very desirable to avoid ineffectual dosage and its use in unsuitable cases, otherwise the bacilli are likely to become resistant

Taking the virtues the limitations and the dangers of the streptomycin group into consideration we would say that

1 In miliary tuberculosis and in tuberculous meningitis it is wholly right

to give the drug in full doses for prolonged periods in accordance with the Oxford plan.

2 In synovial disease and indeed wherever a principal focus appears to be recent, and therefore not yet affected by fibrosis or caseation it should be used in full doses but for periods within the limit of safety

3 Where disease is relatively advanced and therefore most of the bacilli are lying in caseous, ischaemic or necrotic tissues it can best be used in full



FIG 11 Case J.A. Extra articular focus, proved tuberculosis, after erasion under treptomycin umbrella

doses for a brief period before and for perhaps six or eight weeks after any operation

Case J.A

J.A aged 2 years with an extra-articular focus in the neck of the femur (Fig 11) No evidence that the joint was in any way involved; the focus was excised under a streptomycin umbrella 0·25 grammes being given daily for ten days before and ten weeks after the operation, furthermore 2 grammes were placed in the cavity in the bone at operation

Furthermore in every case with a joint in danger both the general and the local treatment by suitable orthopaedic measures should be carried out as carefully as before with close supervision and the periodic application of Thomas's tests During this time and in the subsequent years of aftercare the rise and fall of the patients weight and sedimentation rate should be part of the means of assessing their condition

Para aminosalicylic acid

This drug alone is far less effective than streptomycin but fortunately its use intensifies the effect of streptomycin and tends to modify any resistance acquired by the tubercle bacilli Unfortunately it has a most unpleasant taste and is liable to cause nausea and vomiting At the moment it has to be given five times a day with food It is probable that it may shortly be available in a form which can be administered by injection and less often

Striking *in vitro* tests of the acquisition of resistance by tubercle bacilli to streptomycin and the valuable effect of para aminosalicylic acid in prohibiting or modifying that resistance have been carried out by Grzesko and Pietrowski (1949) *Refs Journ Bact* 57 459-64 1949 They found that tubercle bacilli repeatedly exposed to streptomycin acquired a three fold resistance during the first thirty days but subsequently there was a very rapid increase in resistance which became $\times$ 2 500 after eighty days

On the other hand it was found that when two parts of streptomycin to one part of para-aminosalicylic acid were used in combination at the conclusion of 120 days exposure the resistance was only increased by rather less than $\times 2$.

Cod liver oil

Old fashioned but preferable to the more concentrated conveyors of vitamin D especially in winter and cold weather

THE EFFECTS OF PROLONGED DORSAL DECUBITUS

1 Diminution of vasomotor response to posture

It is, of course well known that after prolonged decubitus patients cannot be raised to the vertical position without faintness The normal control of the circulation in relation to changes of position is out of action and has to be re-educated. Furthermore patients who have been for a long time on their backs are more than ordinarily sensitive to shock during or after operation On the other hand the blood pressure does not greatly vary from normal

2 Renal Calculus

Renal calculus is a dangerous but largely preventible complication of prolonged dorsal decubitus There are three main causes.

First the posture of the patient produces a small stagnant pool in the pelvis of the kidneys

Secondly exposure of the body to the sun and the open air leads to dehydration of the body through skin and lungs These two factors combine to produce stagnation and concentration of the urine which favour precipitation

Thirdly in Pott s paraplegia the urinary tract may become infected

In the authors own hospital where 90 to 100 patients are more or less constantly on their backs, we have records of 8 cases of stone in ten years.

During the last five of which, since we were more alive to the danger there was only one

Many of these so-called stones are for a time at least more mud than stone consisting of a mass of precipitated material which can be fairly easily washed away by the water cure and by changing the posture to the ventral position or by frequent rotation.

Key[1] has made an analysis of renal complications. He investigated 102 cases which had been immobilized for three months or more In these the incidence of renal complications was 19·1 per cent Of 38 comparable cases of less than three months decubitus there was only 1 case The 19·1 per cent represented 32 cases of whom 20 were stone 3 renal tuberculosis, and 9 pyelitis.

The most important sign of renal calculus is haematuria, and ward sisters should be instructed to examine the first samples of urine of every frame or plaster bed patient after each turning Haematuria is an indication for careful X ray investigation.

Renal calculi can generally be prevented several simple precautions must be taken

1 The patients must be persuaded to drink several pints of extra fluid a day
2 Patients must be tilted or turned periodically Practice differs widely in this respect The Pugh frames are mounted so that the patient can easily be tilted to a sufficient angle first one way for twenty minutes then the other several times a day In Oxford the patient is turned formally once a week after the initial two months with the result that renal calculus has become a rarity

The very serious complication of paraplegia presents an altogether different problem which will be considered later

3 Deformities of the lower limbs

Children kept for long periods on their backs in bed are prone to develop knock knee and genu recurvatum, and unless they are given frequent regular exercises for the intrinsic muscles of the feet pes cavus with long heels and clawed toes Persistent care will prevent these deformities. Otherwise they may well be a cause of trouble long after the tuberculous disease is healed Premature closure of the epiphyses of the long bones of the lower limbs is a complication considered later (p 50) and the use of plaster spicas in bed may promote subluxation of the free knee Surgeons sisters and nurses must have and exercise a thorough and practical knowledge of the nursing of frames and plasters they must be fully alive to all the dangers involved and how they can be avoided

[1] Key L. A *The British Medical Journal* pp 1150–3 6 June 1936. See also, The Prevention of Calculus Formation in the Treatment of Tuberculosis of Spine and Hip (*Annual Report of the London County Council* 1933 Public Health, 4 part 3 p 38).

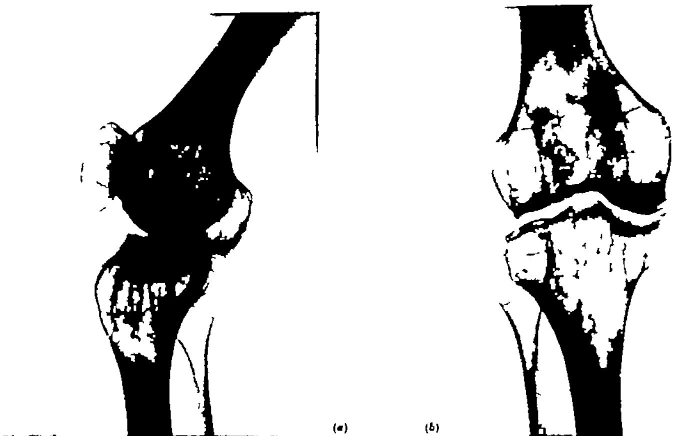


Fig. 1. Examples of secondary deformities.

(a) and (b) Deformity and arthritic changes occurring in the contra lateral knee in a patient treated by prolonged immobilization on a frame for tuberculosis of the hip.



FIG 12 (c) Deformity resulting from premature fusion of the epiphyses in the ipsolateral knee in a similar case

4 The skin

Bed-sores used to be a common effect of prolonged dorsal decubitus. In orthopaedic hospitals they are now very rare This is largely due to the expert nursing on frames, plaster beds and so on

5 The mind

What is the psychological effect of prolonged dorsal decubitus? Taken alone it could not be other than depressing But one can at least do one's utmost by the design of wards, and their direct access to grass and games and life and by opportunities for occupation to make time pass purposefully and pleasantly The systematic education of children while in a long-stay hospital is compulsory in Great Britain Certificated teachers are attached to the hospital and for certain hours each day during term time the ward becomes a school room Thus the children are kept mentally vigorous and do not fall far behind their fellows Adults present a more difficult problem domestic anxiety must be dealt with by the almoner and the surgeon must

make sure that every patient has a fair idea of his programme and prospects Much can be done to see that the patient s time is occupied by some constructive interesting and even profitable handicraft and occupational therapy goes a long way to help in this respect

Occupational therapy vocational training re conditioning and rehabilitation

Many patients admitted to hospital suffering from skeletal tuberculosis will not be able to return to their previous work They will often stay in hospital a year or more and it is very much to their advantage that they should during this time prepare themselves for such future employment as is likely to be suitable for them to take up when they leave hospital

There is thus great need for vocational training as well as occupational therapy Guided by the medical staff the patients should be encouraged to turn their attention to the future and choose at an early stage some work that will be suited to their character mental capacity and physical limitations

For some patients probably perhaps a relatively small proportion there may be direct value in occupational therapy but for the great majority the time spent in hospital can be used with an immense relative advantage if it is directed towards the preparation for some new occupation

Occupational therapy in orthopaedic hospitals was advocated and to some extent practised in the orthopaedic hospitals of the First World War Sir Robert Jones himself and Dr Coldthwait of Boston when in this country were ardent advocates of the practice of some handicraft in restoring the activity of wounded limbs As a result handicrafts were instituted in the wards and workshops for the convalescents were developed in various orthopaedic hospitals The work in the wards was beneficial for hands minds and incidentally the pockets of the men This was genuine if primitive occupational therapy The workshops tended to be used rather for vocational training

These wartime institutions based as they were on sound principles can be applied with equal advantage to the long illnesses of the present day

The choice of occupation is naturally a vital matter and calls for a great deal of experience and judgement on the part of an Advisory Officer (see below) who will, of course be informed by the Medical Staff as to the man s physical possibilities and limitations The Advisory Officer will have to take into consideration not only the man s character mental capacity and physical limitations but also the other side of the problem this is the opportunities that exist for his employment within easy range of his home or in some special industry at a distance

Some patients then, require occupational therapy others vocational training a third group will be able ultimately to go back to their previous occupation provided they can be strengthened by a process of re-conditioning This is best achieved by progressive physical employment designed to re establish the physical condition of their bodies. A man must be not only

healed but fit and hardened, if he is to undertake a full day's heavy work day after day Many a man fails to return to his occupation solely because there is no opportunity for what may be termed occupational exercise

Re-conditioning is a process of restoring the strength and tone of the patient His needs are of course both mental and physical. He has to learn to face and to carry through an arduous day's work. Any form of physical exercise which can be carried out under the direction of a masseuse is piti fully inadequate in this respect Half an hour once or twice a day is, no doubt a beginning but there is an immense gap between that and the strain of a full day's work! Regular employment is needed which can be graduated both in the length of time and the physical demands of the work. The patient having advanced quickly up to a point only too often tends to stagnate and thus fails to reach any sort of physical condition. How much happier and better it is for him mind and body and for all concerned that he should be given some constructive work graduated within his capacity

Then, again, there are some patients who may not need either vocational training or re-conditioning but require rehabilitation alone i e the finding of some occupation of which they are already capable without special pre paration

This of course includes the fitting of a person into a wage-earning occupa tion and covers a very wide field. For the term includes exercise of this function in relation to practically all the patients whether they have been given vocational training or not

We would suggest that an Advisory Officer (non medical) should be appointed with thorough knowledge of all requirements The position calls for a man not only with experience and wide knowledge on the occupational side but one who has a flair for finding employers ready to employ the patients from the hospital who have passed through his hands

The Advisory Officer would be responsible for organizing the whole service with advisory duties in the wards and liaison duties outside

CHAPTER IV

THE LOCAL TREATMENT OF THE DISEASE

Here our aims are

1 To correct any deformity and to favour local healing by rest in a carefully chosen posture

2. To restore free movement whenever possible or if that is impossible to bring about sound ankylosis

3 To remove diseased parts or tuberculous pus when necessary

4 To prevent secondary infection

When treatment is complete we expect the patient s limb (or spine) to be *so well and soundly healed that it will be permanently safe and with its ultimate function so well provided for that at the end of treatment it is freely, strongly, and permanently useful*

We shall see that in most joints these conditions of permanent safety and maximum utility can only be achieved by *free movement* or *sound bony ankylosis*

Our means are various but the basic principle of local treatment is *Rest enforced, uninterrupted and prolonged* as H O Thomas taught us And this Rest includes relief of each constituent part from the strain of its own particular function for the *inflamed synovial and perisynovial tissues* it means *stillness* for the *decalcified and eroded bone* it means *relief from pressure*, and for the *fibrillated and softened articular cartilage* it means *relief from friction and from pressure*

Sir Robert Jones by practice and precept gave his great authority to his uncle s prescription Each word of his pronouncement must be given its full value When we remember that Thomas s father was a successful bone-setter and that previous to his qualification he assisted his father for a year or two his deliberate and conservative methods have added significance

Thomas had a great dislike of plaster, his open splints for the spine and hip were efficient and Sir Robert Jones made them comfortable On the other hand many of us find the advantages of the application of plaster to certain parts and at certain stages greater than its disadvantages But most modern orthopaedic surgeons wisely lay great stress on the value of being able to expose a large area of the body to the air Then again we owe to Thomas an emphasis upon the *continuity* of splintage from the moment when a tuberculous diagnosis has been made to that period, generally at least twelve months later when some modification of the enforced rest can be allowed with safety Thomas was insistent on what he terms *the secondary diagnosis* i e *an ascertainment of recovery* He put the matter thus But it has been overlooked that we ought before releasing the patient from our control to

make a supplementary diagnosis and ascertain that there exists no longer *any remnant of the ailment previously diagnosed.*[1]

Thomas had no radiographs to help him he acquired and he can still teach us to acquire by observation and careful tests at the appropriate time a sure assessment of the progress of the patient Even now with all our X ray and laboratory assistance his methods offer us certain safeguards which we cannot afford to neglect Indeed a great deal of judgement may be required to decide in any particular case when disease is safely arrested One is guided by the patient s general appearance temperature chart and above all by the changes shown in a series of radiographs and locally by the absence of any heat swelling or tenderness The radiographic signs of healing include recalcification and the increasing definition of the outlines of eroded areas.

The authors have already stated their belief that either free mobility or sound bony ankylosis should be our aim, and that only so can we be sure of permanent safety to endure the rough and tumble of life If then the joint surfaces have been seriously damaged it is no longer a question of when we can safely allow movement again. The problem is now one of deciding how best to favour or bring about sound bony ankylosis This involves a change in the application of rest in that while immobilization is kept up interarticular pressure is permitted or even encouraged As natural bony ankylosis is almost unknown in tuberculosis, operation will often be indicated In young children it may be advisable to wait some years before operation can be wisely undertaken, and in such cases we can in due time adopt a form of ambulatory splintage

On the other hand whenever the absence of articular destruction leaves a hope of the restoration of movement there comes a time when the joint is set free provisionally for Thomas s tests Thomas taught that a joint which when set free gains in range of movement is no longer inflamed and is doing well. On the other hand, persistent stickiness i e a reflex muscular resistance to passive movement or a diminishing range of movement is a sure sign that the inflammation is still active and that immobilization must be reinstituted and *maintained for another long period*

In children when inflammation is quiescent and erosion has ceased, there comes a healing stage There is now a constructive hardening of the granulation tissue which has hitherto been a partially organized infiltration of cells, animated by a reaction to inflammation. During this sclerosing stage one can often allow a little movement but cannot safely allow the pressure of weight bearing Then later if all goes well, comes the release from all restraint and protection This convalescent stage is recognized by Thomas s tests and by radiographs

Unfortunately in the majority of tuberculous joints, destruction is progressive until it has become clear that all hope of safe mobility has gone, and that only by ankylosis will the lesion be safely and soundly healed Furthermore we know that bony ankylosis does not happen in tuberculosis, and that

[1] Thomas, H O *Contributions to Surgery and Medicine* 1887 part 3 p 4.

most joints on which considerable strain is thrown will seldom heal soundly without operative arthrodesis

Children heal better than adolescents, adults heal slowly and the elderly never achieve a final arrest In children conservative treatment is carried through to its conclusion both because they heal better than adults and because they stand long-continued hospital treatment better in body in mind, and in worldly circumstance But in adults operation is interposed as soon as general and local conditions allow because they heal poorly, slowly, or not at all and because they do not bear long-continued hospitalization well. But even in some children the time comes when it can be foreseen that without operation healing will be delayed uncertain and probably unsound

The need for operation is often obvious from the first. In an adult for example it is no good whatever hoping for the natural restoration of movement in a tuberculous hip knee or ankle In some joints the infected tissues can be completely excised in others an extra-articular synostosis can be brought about Provided that this removes all strain from the joint the patient can be allowed up as soon as his general condition will benefit thereby We can then accept the principle that operation will accelerate sound healing and often bring it about when it would not otherwise take place but we cannot afford to forget two vital principles

(1) that the operation on a joint has no direct influence on the deep-seated lymphatic tuberculosis, and

(2) that the operation will be far more certain of success if it is done at a stage when the general condition of the patient is at its best and the local lesion is no longer active.

One ought then in general to wait for health and for X ray evidence of recalcification But operation may be indicated for a different reason, not at a chosen moment and at a favourable stage but because the local lesion remains active in spite of treatment and because the toxaemia is itself a danger to life and a bar to recovery For example one may feel it advisable to perform thorough excision of the focus in the hip or excision of the knee in older patients in order to give relief from a massive tuberculous focus. One should not hesitate to amputate the leg of a man over 40 with a widespread active tuberculosis of the tarsus

Again in caries of the dorsal spine in an adult there may be *persistent* pain which cannot be controlled by a frame or a plaster bed because it is associated with respiration In such cases the movements of breathing seem to be concentrated exactly at the point of somatic destruction The authors have actually seen this movement taking place two or three times while clearing the debris round the lesion after costotransversectomy Raw infected bone above and below was being ground together This harmful and *painful* grinding can be quickly relieved by strong posterior bone grafting and finally eliminated when posterior fusion is complete Then too paraplegia may call for operation at any stage of the disease

One cannot lay down a period for operation which will be universally true for the indications and the circumstances vary with the individual case

Persistent grumbling activity

Sometimes in children and adults there is a failure to establish sound healing This is due to the lack of one or both of two fundamental factors in healing a sound mechanical stability covering the site of the disease and the patient s recovery of full vitality and resistance In the elderly this extremely unsatisfactory state of affairs is so common that it has altered the indications for treatment indeed whenever tuberculosis of the hip knee ankle or foot has become established in an elderly person amputation is likely to be the best and safest line of treatment In the upper limb of course amputation can almost always be avoided (except for a finger which can be spared) Disease which has started in childhood may be found continuing far on into *adult life because those responsible for the treatment have not insisted upon* the achievement of bony ankylosis by arthrodesis. The authors have seen a number of patients who have suffered pain for years on this account and in some cases their deformity has gradually increased until it has become extreme These patients have on the other hand developed an adequate general resistance to the disease which has only remained active in the hip because of mechanical strain In such instances operation to correct the deformity and to promote sound healing can be carried out with little delay and without prolonged hospitalization These are the cases in which the surgeon is able to regard the metastatic lesion objectively and in isolation since the primary lymphatic disease has long ago healed.

Splintage

The splintage should

1 *Hold the parts accurately and comfortably in whatever position is* chosen.
2 Allow free circulation in the affected part
3 Allow free respiratory movements
4 Allow as much exposure of the surface of the body as possible to the air
5. Be as simple inexpensive and widely applicable as possible In the application of this splintage great care should be taken to avoid producing secondary deformities of other parts, and when prolonged decubitus is necessary everything possible should be done to eliminate stagnation as well as concentration of the urine
6 In spinal caries allow access to the back whenever necessary without risk of local strain or movement and, where bone destruction has made a local kyphos inevitable and even desirable for the sake of sound healing and stability enable it to be minimized and localized and compensatory curves to be developed

But there is no such thing as fool proof splintage Nor can the use of the

various splints frames and plaster beds be easily learnt out of a book yet it is only his intimate acquaintance with their uses and their dangers that enables the expert to keep his patients comfortable safe and at rest Every surgeon responsible for these cases must acquire this knowledge by close personal attention to the details of nursing in the wards and by taking every opportunity of discussion with old hands at the craft whether they be his senior colleagues or his ward sister He must be aware of every danger and how to avoid it by the use of some pad or pull and know what can rightly be done and what must not If his patients are to be on frames in a hospital unused to frames he will run up against trouble unless he is fully competent to nurse a frame himself Evidence of a lack of this knowledge is all too often seen in the form of patients who years after the completion of their treatment and the sound healing of their tuberculous lesion are still suffering from disabilities due to faults of splintage or of the method and extent of immobilization Irreparable damage may have been done

It is above all disastrous to allow any interference with the circulation of the part or any circumferential compression of an inflamed joint Whenever possible splintage should permit free access of light and air to the unaffected parts of the body If an appliance is still required when the patient gets up it should be our aim to make it as light rigid durable and comfortable as is consistent with effective control

In an appendix (p 287) will be found a description and some illustrations of various standard splints and appliances together with a few hints on the use of plaster of Paris, and an indication of some of the difficulties and dangers associated with these methods of immobilization.

CHAPTER V

OPERATIVE TREATMENT

A For Diagnosis (already considered in Chapter II)
B For Cold Abscess
C For the Prevention and Treatment of Secondary Infection.
D Directed toward the elimination or healing of the Focal Disease these include
  (i) Treatment of extra articular bone foci
  (ii) Excision or erasion of joint disease with intra-articular arthrodesis
  (iii) Extra articular arthrodesis alone or in addition to the above
  (iv) Wide excision of all infected parts with subsequent pseudarthrosis o amputation
E. For the Correction of Deformity
F For Paraplegia (to be considered later in Chapter VIII)

THE TREATMENT OF A COLD ABSCESS

A cold abscess develops very slowly and causes no pain so the patient i often unaware of its existence for a long time It may even undergo spontaneou rupture with grave risk of secondary infection before any mention of it i made For this reason it is most important that all patients in hospital fo skeletal tuberculosis should be examined thoroughly and frequently Ar abscess *can be harmful both from the toxaemia it produces and from it* pressure on vital structures such as the spinal cord it may further b threatening on account of prospective rupture and secondary septic infection

The microscopic examination of the wall of a cold abscess shows that i is more than a mere collection of the products of destruction and reactior poured out from the skeletal focus The formation and extension of such ar abscess involves the infection of the surrounding tissues by tubercle bacilli *thus its walls contain active tuberculous follicles (Fig ɔ) There are however* great variations in the degree of this capsular tuberculosis and it is fortu nately the rule that its quiescence follows the healing of the skeletal lesion and if need be aspiration of the abscess Now and then a late residual abscess may give a little trouble on its own account

The *aim of the treatment of a cold abscess is to promote its disappearance* without the formation of a sinus On general principles such an abscess should be aspirated but sometimes where it is deeply placed and shows no tendency to come to the surface or increase in size it is best left alone for the time being since it is likely to diminish as the disease becomes quiescent furthermore deep aspiration is not without its complications

Aspiration should be undertaken only after due consideration and with the most careful aseptic precautions It can be carried out under local anaesthesia

in adults but in children a general anaesthetic is best The contents of a cold abscess vary widely in consistency from a thin watery fluid to thick flocculent pus Sometimes a combination of the two is found a thin fluid with flakes of semi-solid matter One should begin with a fairly fine needle and always use the narrowest that will succeed since a wide bore needle is more likely to lead to leakage and infection of the track The needle should be inserted through healthy skin some distance from the abscess so that its track is long and oblique and if possible it should pass through muscle rather than lie directly under the skin The point of entry of the needle should be anaesthetized and then a small incision made with a tenotomy knife. This is advisable because a medium bore needle kept in some time during the aspiration is likely to leave a gaping hole with the edges of the skin stretched and white If the flow of pus ceases before the abscess is nearly empty it is likely to be due to a small plug of material in the needle and a little air should be injected to free the aperture This is repeated as often as necessary and again before the needle is withdrawn for if this is not done a tiny piece of infected material may be deposited in the needle track leading to its infection and the formation of a sinus Various fluids have been recommended for the modification of the obstinate contents of an abscess in the authors experience they have proved far from satisfactory in that the pus is little more amenable to aspiration and repeated attempts weary the patient and end in a sinus.

The fluid withdrawn should be examined by smear and culture and it is helpful to be given a rough assessment of the numbers of tubercle bacilli seen in the smear as this gives some indication of the activity of the infection

But aspiration is sometimes unavailing perhaps most often in the ankle, wrist foot, or hand, then comes the choice between opening, evacuating, and closing or opening and allowing leakage under the most careful control When the abscess can be incised through healthy tissues suture of the wound is desirable in the hope of primary healing. Before the wound is closed all bleeding must be stopped the cavity should then be carefully washed out to ensure that no infected necrotic material is left All the sutures deep and superficial should be tied very gently for tight sutures cause ischaemia or necrosis and favour infection It should be unnecessary to mention that such a procedure should only be undertaken with full aseptic ritual and under the protection of chemotherapy (see p 47) On the other hand where the abscess has come near the surface the superficial tissues are almost certainly devitalized and closure after incision should not be considered In our experience secondary infection can be prevented by sufficiently careful technique including the application of a special antiseptic to the skin, both at the operation and afterwards at every subsequent dressing After its evacuation the cavity is allowed to leak, and any form of rubber or gauze drain is abhorred the incision is of good length the whole length of the subcutaneous cavity and is not sutured.

Infection may reach the sinus by direct spread from the skin by inadequate

dressings which do not prevent contact of fingers or bed clothes, by implantation or by airborne infected droplets or particles during a dressing. Any hospital in which this type of case is treated should have a definite routine laid down for the dressing of sinuses and these rules should be rigidly kept

1 No dressing should be done in the ward.
2 The cleaning of the room in which dressings are done must have been completed at least one hour previously
3 Flies &c must be kept out by adequate fly proofing and the use of D.D T
4 Blankets must be removed and replaced by clean sheets before the bed is brought into the room.
5 No one *patients or staff* is allowed in the room at the time of the dressing or for at least 15 minutes before without an adequate mask
6 All dressings must be done with full aseptic precautions and an impeccable no-touch technique
7 The skin for an area of 6 inches around the sinus must be painted with a mixture of 1 per cent crystal violet and 1 per cent brilliant green in 70 per cent alcohol
8 The dressings must be extensive of non absorbent wool and be bandaged firmly in position (*never little pads of gauze stuck on with adhesive*)
9 A clean case must never follow a septic one
10 The dressings must be thorough unhurried, and infrequent For a few days daily dressings may be necessitated by profuse discharge but in the absence of pyogenic infection there is soon very little leakage and dressings once or twice a week suffice
11 Repeated bacteriological examination of the discharge from a sinus and should pyogenic infection have occurred the fault should be sought and the sensitivity of the bacteria to penicillin investigated.

THE PREVENTION AND TREATMENT OF SECONDARY INFECTION

(1) The prevention of sepsis

Pyogenic infection when it occurs is almost always a late complication but very rarely a tuberculous and pyogenic infection appear simultaneously with the signs and symptoms of acute osteitis Such a case must be drained for sepsis and put through the standard general and local treatment for tuberculosis

Ordinarily pyogenic infection can and should be avoided by

1 Early and adequate general and local treatment which limits bone destruction and abscess formation.
2 The aspiration of abscesses coming toward the surface in good time and by a long track

2. *Meticulous aseptic and antiseptic dressing technique* of any sinus (see above)

This in the Wingfield Morris Hospital has proved so reliable and beneficial that it deserves emphasis If a tuberculous focus has been well treated and the patient is doing well the discharge from that focus will very quickly lessen and dry up Within a few days or weeks the whole thing is healed For a period of five years we had not a single case of secondary infection of a tuberculous sinus

In the old days secondary pyogenic infection of a sinus was almost universal with the tragic results we knew only too well—unending illness periods of pyrexia profuse suppuration lardaceous disease and a slow and miserable death

(ii) The treatment of sepsis

Sepsis has always been one of the most serious complications to be met in the treatment of bone and joint tuberculosis Its surgical treatment is the standard treatment of sepsis anywhere i.e adequate drainage and this may be difficult

Surgical measures should be combined with chemotherapy systemic (see p 30) and local Here the sinuses are syringed daily with streptomycin and penicillin in the proportion of 1 gramme streptomycin with 200 000 units of penicillin dissolved in 1 per cent C T.A B

Streptomycin 0·25 gramme with penicillin 50 000 units can with advantage be injected into a closed abscess Usually this injection is carried out after aspiration every two weeks

THE ELIMINATION OR HEALING OF THE FOCAL DISEASE

(i) Treatment of extra articular bone foci

What are we to do when there have been signs or symptoms of arthritis and X rays disclose an extra articular focus without evidence of infection of the joint? In cases in which the focus appears definitely extra-articular one is sorely tempted to curette it through an extra-articular approach Calvé has warned us against doing so until progress has made it clear that the joint is not infected His warning concerns the danger of sinus formation with secondary infection of the joint via the sinus In the authors limited experience of such an operation no long-continued sinus with a risk of sepsis has occurred but on the other hand, when signs of arthritis have called attention to the lesion, the joint itself has already been infected with tuberculosis

Osseous foci quite definitely non-articular may be discovered on account of symptoms of endosteal rather than arthritic origin perhaps an indefinite aching in a bone or the appearance of fluctuating swelling rather than pain or lack of function in a joint Such a condition occurs not infrequently in the sternum a rib or in the small bones of hand or foot These can be dealt with by limited surgical measures and the basic infection by general treatment

(ii) Excision or erasion of joint disease with intra articular arthrodesis

This is carried out in order to obtain sound, safe, and permanent healing The arthrodesis may be preceded by the removal of all, or as much as possible, of the diseased tissues of erasion or excision. The advantage of this is that it enables the surgeon to eradicate the diseased tissues partly or completely, and to place together raw surfaces of healthy bone In some parts, notably the knee erasion or excision with direct arthrodesis is adequate In many joints however some form of extra-articular arthrodesis is essential either as a supplement to excision or without any articular operation

Sir Robert Jones used to insist upon the difference between tuberculosis in the old and the young teaching that when excising a joint in a relatively young patient one could leave infected tissues, but that in the old one should regard them as locally malignant

(iii) *Extra articular arthrodesis*

This, as its name implies is a procedure which aims at synostosis by means of bone transplantation from a point proximal to a second point distal to the joint without opening the joint The great advantage of this method of synostosis is that the bone bridge is at a distance from the tuberculous lesion for *osteogenesis does not occur except at a distance in time or in place from an active tuberculous focus* In other words if the surgeon endeavours to get union between two bony surfaces close to a recent even if no longer active tuberculous lesion he will fail but if he can by a graft between the two bones build a bridge which makes contact with healthy bone at a distance above and below the joint osteogenesis will be unhampered.

Technical principles The methods will vary with the joints concerned but the principal points can be stated as follows

(*a*) The graft should have good contact at both ends with raw healthy bone
(*b*) The shorter the bridge the better
(*c*) The placing and the shape of the graft should be related to the mechanical strain likely to be imposed upon it

Not only are there good and bad technical methods in the operation itself but also in the splintage and protection of the joint during the operation and in continuity afterwards Finally there must be a carefully graduated exposure of the grafted joint to the strain of use in order that the bone bridge may strengthen until it is able to stand any load which may be put upon it

(iv) Wide excision of all infected parts with subsequent pseudarthrosis or amputation

Extensive disease. Now and then there may be a very large area of bone infiltrated by tuberculosis and in the end practically replaced by a granuloma permeated by tubercle bacilli This massive disease may involve the bone at *one or both sides of the joint* and the joint itself will of course be destroyed

and its cavity occupied by debris and necrotic tissue This may make arthrodesis exceedingly difficult or even impracticable and may of necessity indicate *wide excision* or *amputation* Furthermore even though it should prove possible by conservative measures to arrest the disease this would at best take several years and at the end the joint would have been destroyed the bones shortened and the limb wasted

The justification for wide excision in such a case is a better prognosis and a much quicker prospect of recovery

Persistent active disease Occasionally a patient fails to respond to treatment Sometimes the local lesion alone will persist despite improvement in the patient s general health Month after month the radiographs make it clear that further bone destruction is taking place There is no sign of the arrest of the destruction still less of recalcification At other times the patient as a whole fails to respond remaining much as he was when admitted to hospital Such a state of affairs is rare in children but by no means uncommon in adults Whereas in the former case radical excision will as a rule be successful in the latter the problem is not so straightforward It may be that the man s illness is due to an active lesion of a large joint or on the other hand it may be that there is some other lymphatic or pulmonary lesion which is responsible A careful general examination will be made but even so a great deal of consideration and good judgement may be needed in order to reach the right decision on the question of operation The problem is sometimes of this sort Is it probable that the local lesion is alone responsible for a man s illness and that relief from toxic absorption will enable the man to recover from any other lesion he may have? Or on the other hand is the local lesion active only because of the man s general illness and will any operation be futile or definitely harmful?

The operations that will have to be considered in such cases are radical excision or amputation

Occasionally amputation of a limb must be undertaken sometimes as a life-saving procedure The indications may be either local or general. The local indications will be considered in the chapters dealing with individual lesions. Sometimes however we find a patient with several active lesions and obviously going down hill Under such circumstances complete eradication of a major active focus by amputation may well tip the balance in favour of the patient

Pseudarthrosis. A very wide excision of the diseased bony parts may be necessary in certain cases so extensive that arthrodesis may be impracticable In order to maintain length and provide the immobilization of the soft parts that favour healing strong uninterrupted traction is essential from the time of operation e.g in the hip the upper end of the femur must be kept well away from the innominate bone

It has already been stated that the aim of treatment in articular tuberculosis is free movement whenever obtainable or sound ankylosis when the articular surfaces are destroyed, This wide divergence of aim is explained by

the experience that a limited range of movement is likely to be painful and to favour a local recurrence of the disease it is indeed sometimes the cause of long continued grumbling activity

In many conditions good orthopaedic splintage will eliminate the need for subsequent correction of deformity and in all cases the surgeon must review the situation in relation to ultimate ankylosis as soon as the hope of healing with free movement has to be abandoned unfortunately this applies to the majority of patients. From this time onwards he endeavours to hold the parts immobilized in the position of choice with a view to ultimate ankylosis

Often however the patient reaches the surgeon with the disease active and the parts already fixed in deformity by spasm, contracture, and granulation tissue We then have three alternatives The first is to correct the deformity without delay by splintage or by passive movement under an anaesthetic followed by immobilization The second is to do so by open operation at some subsequent carefully selected time The third is to leave the deformity unchanged and do what is possible to produce compensatory curves above and below in order to improve the ultimate general alinement

FOR THE CORRECTION OF DEFORMITY

Spine

Here the intrinsic deformity varies with the extent of destruction and the site But this organic deformity is liable to exaggeration especially in the dorsal region by the absence or distance of compensatory curves Most of us aim at the elimination of all but the essential orthopaedic stability of Menard by the minimization of the length of the primary kyphos and by the development of compensatory curves close above and below Waldenström[1] (see Figs 62*a* and *b*) has gone further and succeeded in straightening the kyphos and maintaining the correction by grafting

Lower limbs

Here angular deformity can to a large extent be prevented by good splintage and when necessary corrected by osteotomy but the worst and the most intractable deformity is the shortening and wasting of the bones of the limb in children due to

1 Destruction of bone by disease
2 Relative atrophy from disuse
3 Premature closure of the epiphyses of the limb (Figs 12*a* *b* *c*) The explanation of this occurence is not yet fully understood.[2]

When there is premature closure of the lower epiphysis of the femur and upper epiphysis of the tibia in a young child with hip disease it may result in extreme shortening even up to 6 or 7 inches. This is seldom if ever seen in limbs which have been immobilized for less than two years

Waldenstrom, *Acta Chirurgica Scandinavica* 56 Fasc v 1924.
Phemister D B., *Journal of Bone Joint Surgery* 1933, 15, 1

All these sources of shortening can be countered by early diagnosis of the disease and its prompt efficient treatment thereby reducing the period of immobilization and promoting an early return to active function Extra articular arthrodesis may be of special value in this connexion Furthermore in hip disease in young children where long continued immobilization is sometimes needed some controlled movement of the knee may be allowed after the first year

Sometimes however operation is indicated to equalize the length of the lower limb or at least to reduce the disparity This may be effected in two ways by shortening the long leg or by lengthening the short one The authors prefer the former This may be accomplished exactly and at the cessation of growth by the excision of a piece of the shaft usually of the femur only but occasionally also of the tibia An alternative method directed to arresting the growth of the unaffected leg was recommended by Phemister he used bilateral cortical grafts but Blount and Clarke[1] have recently advocated placing large staples across the epiphyseal line The latter method is said to have the advantage that when the staples are removed growth will continue but further investigation of the method is still required before the present authors can take the responsibility for recommending it In any case the age for the performance of epiphysiodesis femoral tibial or dual must be judged in relation to the shortening and the expectation of growth in the affected limb A table has been worked out by Green and Anderson[2]

The dangers of operation

In relation to danger the operations are of two orders

1 Those done for purely orthopaedic reasons e.g spinal fusion arthrodesis osteotomy epiphysiodesis leg lengthening &c
2 Life-saving operations done to check dangerous disease e g amputation wide excision &c

The surgeon must satisfy himself of the safety under the circumstances of an operation of the former group before deciding on its performance On the other hand as regards the second group having taken every precaution the surgeon is often right in facing grave risks.

Is there a risk of dissemination? It is of course axiomatic that unnecessary operations on sick patients should be avoided In tuberculosis one should consider not merely the risks directly associated with the operation itself but also that of a subsequent and perhaps prolonged physical depression a state particularly unfavourable in a tuberculous patient The opponents of the operative treatment of tuberculosis have indeed put forward the view that operation involves a considerable risk of dissemination of tuberculosis It is therefore of great interest to note that during the thirty years in which the Wingfield Morris Orthopaedic Hospital has dealt with surgical

[1] Blount W P and Clarke G R. *Ibid* 1949 31 464
[2] Green, W T and Anderson M., *Journal of Bone Joint Surgery* July 1947 29 659

tuberculosis on a large scale we have no record of a case in which a new focus or meningitis or miliary tuberculosis, has followed an operation during the three or four months in which the operation might reasonably be regarded as responsible

We have had a case or two in which an operation was done rather as a forlorn hope in order to relieve a seriously sick patient from a painful and exhausting lesion, and some of these patients have continued to go downhill

The authors attributed the absence of dissemination after an operation in the main to the preparatory course of general treatment as a rule the patient is not operated upon until he or she is definitely showing a good resistance to tuberculosis, and it is, therefore unlikely that tuberculous bacillaemia will give rise to new lesions Two patients developed meningitis while in hospital fortunately before not after operation which if it had been done a few weeks earlier might have been unfairly blamed

CHAPTER VI

THE HIP

THE spine and the hip suffer from tuberculosis more often than any other part of the skeletal system and the hip more often than any other single joint The hip therefore will be considered first and in order to avoid

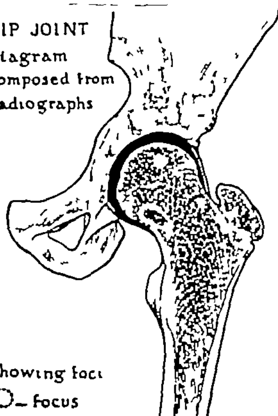


FIG 13 Diagram indicating fairly typical foci round the hip.

cumbersome repetition differential diagnosis will be discussed in detail in th chapter In the later chapters particular points in differential diagnosis wi alone be taken.

PATHOLOGY

A metastatic infection may be deposited in any single part, or simu taneously in several parts of the joint and its constituent bones The fo which result may be synovial or and it amounts to much the same thing ma be juxta-synovial ulcerating the bone where the synovial membrane joins i or again the foci may be situated anywhere in the head and neck of the femu or round the acetabulum most often in its roof (Fig 13)

The localization of the original focus is sometimes of practical importance for operation may be indicated in the case of a metaphyseal focus which appears to be entirely extra-articular (Fig 14) or a tuberculous embolus may cause infarction as well as infection the early X ray signs of aseptic necrosis



Fig 14 A metaphyseal focus.

being subsequently replaced by those of tuberculosis Such an embolus, blocking one or more of the branches of the vessels passing to the epiphysis via the ligamentum teres may cause initially the radiographic appearance of pseudocoxalgia (Perthes disease) Occasionally the concentration of disease in the acetabulum appears to warrant some form of acetabulectomy and in some cases a very widespread endosteal destruction of the head neck and *trochanteric region may indicate a wide excision of the affected parts of the* femur These points will be discussed later

The hip is a close-fitting ball and socket joint and one of the difficulties in its treatment is a tendency for the debris of its destruction to collect in the socket hyaline cartilage is resistant to tuberculosis the bone under it is

eroded until the articular cartilage is sloughed off and lies among the debris collected deep in the socket the whole forming a mass of sloughed cartilage bone sand and pus which prevents the femur from making direct contact with the ilium Such a joint remains unhealed insecure and not easily or fully protected by extra articular arthrodesis Sometimes however the capsule is ruptured and the debris extruded in one or more directions X rays frequently reveal such extrusion sacs filled with calcareous debris This extrusion is of benefit for what is left of the femoral head can settle into the acetabulum —and in so doing shorten the distance to be covered by a graft and take a share in the resistance to strain

DIAGNOSIS

History

A limp is almost always the first symptom of hip disease and the limp is characteristically due to a loss of full extension of the joint There is normally a moment at the end of each step when the hip is fully extended but whenever there is synovitis or arthritis of the hip this full extension is lost, and the loss is evidenced by a limp what is termed a flexion limp of the affected limb It is this limited extension of the hip more than any delicacy in putting the foot on the ground or transferring body weight to the limb which exhibits the disease The characteristic limp of hip disease is not one of pain, it is rather one of impaired function "The limp is due to the inability of the patient fully to extend the thigh on the pelvis more than to any conscious protection of the joint "[1] At the same time the movements of the joint are not quite supple on account of the reflex hypertonus of its muscles and this limp is quite different from the yielding dip of unilateral congenital dislocation of the hip or the carefree stumping of coxa plana after the initial arthritic stage But it must be remembered that in an early case *the limp may not always be present on examination* especially if the child has been put at rest for a few days Indeed the characteristic history is that of *a limp which becomes obvious when the child is tired*

In an adult pain in the hip or pain referred to the thigh or the knee is the rule This pain is severe whenever the joint is tightly distended with fluid. In a child pain is often not mentioned but in many cases we hear of restlessness at night or night cries i e the child wakes with a sudden whimper or cry just after he falls asleep Such a story is very strongly suggestive of tuberculosis

Often the patient is below par and mothers will have noticed that the children have been easily tired and not at all in their best form for some months This is of course associated with the primary tuberculosis of the lymph glands.

Clinical examination

The patient should be examined lying on a firm flat couch or even better on a table covered with a blanket

[1] Robert Jones, *Contributions to Orthopaedic Surgery* p. 123.

It may now be noticed that the patient is lying with one leg apparently a little longer than the other due to abduction also that he keeps one or both hips a little flexed or lies with marked lordosis For at an early stage patients often hold an inflamed and distended hip abducted and externally rotated and always a little flexed, though this may be masked by lordosis Later on the unrestricted result of prolonged muscular spasm will have led to adduction but the flexion remains

Careful comparative inspection will reveal wasting of the thigh probably some swelling in front of the hip and wasting and loss of firm outline in the buttock. *Measurements round the thighs taken at exactly comparable distances* below the anterior superior spines will confirm the wasting. Tenderness is almost always present in adults but less constantly though quite frequently in children. Actual measurements from the inferior aspect of the anterior superior spine of the ilium to the tip of the corresponding internal malleolus on each side are not likely to be different at an early stage But owing to muscular spasm it may be impossible to get a comparable position for each hip and knee for abduction and flexion shorten, whilst adduction and extension lengthen, actual measurements. Destruction, displacement or in old cases diminution of growth from disuse may be responsible for true shortening

Practical (apparent) measurements are only helpful when one hip is fixed (whether by muscular spasm or by fibrous or bony ankylosis) To test this, the free limb is brought side by side with the fixed Measurements are then taken from the umbilicus to the tip of each internal malleolus (the heel of the hand holding the tape should rest firmly on the iliac crest) the short leg being measured first, then the longer, with equal tension on the tape Any difference in the two sides must be interpreted in the light of the actual measurements If the practical shortening is greater than the actual, the fixed hip is adducted, if less, it is abducted The difference between actual and practical shortening when related to the distance measured transversely over the anterior superior iliac spines, will furnish the angle of abduction or adduction by means of Lovett s table (see p 310)

The patient is now asked to flex both limbs right up The movement is compared and the hips are then tested in turn for flexion deformity *(Figs. 15 and 16)*

The sound leg is examined first, and put slowly and gently through its movements. The good knee and hip having been flexed until with the thigh pressed on to the abdomen, all lumbar lordosis is obliterated (but no farther or the pelvis itself will be flexed on the spine) This position is then carefully held and the child is asked to lay his other leg flat on the table If he attempts *to do so and cannot or if he does not try and gentle assistance is resisted*, one has a positive answer to the flexion deformity test which indicates the slightest commencement of hip-joint malaise [1]

The affected limb is next held very steadily by the knee and movements

[1] H O Thomas, *An Argument with the Craser* p. 9

are attempted very slowly and so gently and tentatively that however sensitive the hip may be it is not hurt If the pelvis moves with the thigh flexion is stopped as soon as all the lordosis is lost and the patient is asked to put the good leg on the table for comparison This he can do showing that in this hip there is no flexion deformity

Then the examiner standing at the foot of the couch and taking one foot in each hand gently rotates both limbs watching the whole pelvis and comparing the range of external rotation and internal rotation on the two sides



FIG. 15. Flexion deformity



FIG 16 No flexion deformity

Abduction is then tested the examiner asking and assisting the child to separate his legs as widely as he can, while he watches the anterior superior spines closely for tilting If there is arthritis of one hip all its movements will be limited by muscular resistance, being less free and full than those of the other hip It is not always possible to demonstrate this in regard to rotation, but whatever loss there is will be balanced therefore an unbalanced loss, say of internal rotation is suggestive of another diagnosis, probably adolescent coxa vara or very rarely of adhesions in the gluteus maximus Similarly a flexion deformity with free rotation may be the result of psoas spasm due to a subacute appendicitis or to osteitis of a lumbar body or transverse process *No attempt should be made to overpower the resistance at the limits of movement* The whole of the examination can be made without causing any pain and even without inducing any movement of the joint if the disease is active and the sensitive hip fixed by muscular spasm To force movement is harmful and *examination under anaesthesia is useless and dangerous* The symptoms and signs described are characteristic of tuberculous disease of the hip but they are not in any sense pathognomonic The signs and symptoms show that something is irritating the hip and causing an arthritis which is like that due

to tuberculosis but nothing more It may be as we shall see due to other causes, but the important thing is that the patient should be promptly admitted to an orthopaedic hospital on a *provisional diagnosis* of Observation Hip to start treatment and await exact diagnosis Expert radiography is an immediate need but *negative radiographs do not exclude tuberculosis* This can hardly be repeated too often!

Limp and limitation of movement in all directions by muscular spasm are reliable proofs of arthritis of the hip Nevertheless their absence does not exclude an endosteal focus without infection of the joint One should bear this in mind when the general condition of the patient is suggestive of tuberculosis and pain is felt in the region of the hip Under such circumstances insist upon obtaining very good stereoscopic radiographs then study them very carefully, for small endosteal foci are elusive! If such foci remain unrecognized the disease may spread and infect the hip but this catastrophe can probably be prevented in some of such cases by the discovery and eradication of the focus by an extra-articular route

Confirmation of diagnosis

The patient has now been admitted with arthritis and it remains to distinguish tuberculosis from other sources of inflammation. For this we have more and more come to rely upon radiography A radiograph will often settle the diagnosis straight away at other times a series taken at suitable intervals will do so The radiograph will as a rule include both hips for comparison, and in some cases be stereoscopic in order to demonstrate endosteal foci or slight antero-posterior displacements of the femoral head The characteristic effect of tuberculosis is a localized fading of the bone shadow a similar fading occurs with disuse but is more diffuse

Radiographs

Localized erosion without reaction (Fig 17) is characteristic of tuberculosis and the picture is different from the clearly defined *lesions of syphilis (Fig 18)* and the necrosis or proliferation associated with septic infection (Fig 19) During the early period of evolution, *the X ray evidence lags far behind the actual extent of pre-erosive invasion of the bone* Bone infiltrated and rotten with tuberculosis when seen by the surgeon's eye or felt by his finger may have appeared of normal structure (though relatively decalcified) in recent radiographs (see p 18)

Skin tests

In all cases a Mantoux intradermal test is carried out Negative tests at all ages are valuable positive only in young children but in a very ill patient with rapidly progressive disease a negative skin reaction does not exclude tuberculosis



Fig 17 The decalcification and erosion of tuberculosis.

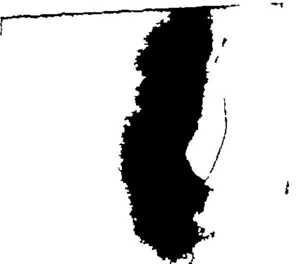


Fig 18. The destruction proliferation, and sclerosis of syphilis. Note lipping of acetabulum and sclerosis around focus. Distinguished from tuberculosis by radiograph and Wassermann reaction.



Fig 19



Fig 20

Figs. 19 and 20 Show appearance of two types of pyogenic infection involving the hip joint. Fig 10 shows the dense hard sclerosis of the femur as compared with the honeycomb appearance in Fig 20 in which the ilium is principally involved resulting in much new bone with an indefinit hairy outline

It is not unknown for the type of disease shown in Fig 20 to be mistaken both clinically and radiologically for neoplasm. The involvement of both elements of the joint is in favour of the diagnosis of inflammation rather than neoplasm (cf. Fig. 25).

Blood tests

A Wassermann test should be undertaken in all cases or at least whenever there is anything suggestive of syphilis A differential blood count is useful when the diagnosis lies between tuberculous and pyogenic osteitis the former producing a relative increase in lymphocytes the latter in polymorphonuclear cells Furthermore if pus is available by a piration it should be fully examined

DIFFERENTIAL DIAGNOSIS

Quite often diagnosis remains in doubt and then our procedure differs in children and adults In children treatment is carried on for a further period as if the hip were tuberculous under the provisional diagnosis of Observation Hip But in adults the differential diagnosis is less difficult and time is more valuable the hi tory is characteristically in idious, the whole picture being that of subacute or chronic monarticular arthritis, two or three serial radiographs show progressive decalcification with early signs of erosion Whenever necessary both in children and adults the diagnosis can be made by a regional gland biopsy

1 Transient arthritis of the hip

This is a clinical term applied to an arthritis or synovitis which responds to treatment in a few days or weeks It is probably usually due to streptococcal infection from the pharynx or intestine, All patients with observation hips are put at once on some form of immobilization—in the authors present practice on a Robert Jones double hip frame (see p 301)

The distinction between tuberculosis and transient arthritis is made by clinical progress after the search for and elimination of likely sources of streptococcal infection Transient arthritis is suggested by the persistent absence of radiographic changes other than those of the decalcification of disuse associated with a non-destructive arthritis When this is so after immobilization on the frame for a period estimated on clinical grounds and varying from a fortnight to six or eight weeks, the patient is taken off the frame and examined If the hip feels promising if the movements are free within limits and not associated with muscular resistance the patient is set free in bed. In two or three days and again in a week, the movements are examined If the joint is still sticky and there is muscular resistance he is put back on his frame as an observation hip for six to eight weeks and then put through the test again. But if on the other hand the movements were gaining freedom during the first week, they are tested once more after another week s freedom in bed, if there is progress the patient is allowed up in the ward, and if all goes well for another week he can go home

2 Osteochondritis of the femoral head—(pseudocoxalgia)[1] Age-incidence 6–12.

This is an ischaemic disturbance of the epiphysis which if untreated leads

[1] Platt *British Journal of Surgery* 9 306.

to a flattened head and a thickened neck producing in fact a coxa plana (Fig 21) If however the condition is recognized early the hip must be immobilized until the period of reaction is over, and the head must be protected from compression during the long period of disorganization and feeble growth Actually this takes several years Of these the first should be spent



Fig 21 A fairly early case of pseudocoxalgia.

in bed but later on the patient may be allowed up if one can rely on unremitting protection of the head by an exactly fitted weight bearing caliper The affected neck will always be thicker than the normal but the spherical form of the head can be restored, and this is a very great achievement for the distorted femoral head of untreated or imperfectly treated pseudocoxalgia inevitably leads to the onset of osteoarthritis in middle life (Fig 23) The lesion is non-erosive—bone suffers, cartilage does not The bone cells suffer death or suspended animation, but the cells deep in the hyaline cartilage find sufficient nourishment to maintain their existence and multiply. The children always recover with a mobile hip. In the past pseudocoxalgia



Fig 22. Avascularity of part of the head f the femur following trauma. Case of fractured neck of femur treated by nailing The avascular part of the head is sclerotic and the neighbouring articular cartilage almost obliterated. Compare with Fig. 1



Fig. 23. Old pseudocoxalgia with distortion of the head and corresponding adaptation of the acetabulum.

as its name implies was mistaken for true hip disease and the end results, so much better than those of tuberculosis, misled the profession and falsified statistics

Very rarely tuberculous hip disease starts in the semblance of Perthes disease ischaemia of the epiphysis results from a tuberculous embolus of the artery in the ligamentum teres. This is truly a wolf in sheep's clothing



FIG 24 Tuberculous left hip. The earliest radiographic sign was the relative sclerosis of embolism. This was followed by the radiograph shown. Thus the sign of a vascular accident was followed by that of decalcification due to tuberculous infiltration.

and the deception calls for early exposure, if only on account of the very different evolution of the two conditions The general condition may be significant but the disguise is unlikely to be detected unless serial radiographs are closely examined The X ray indications are at first those of ischaemia (see Fig 24) and therefore completely deceptive because contrary to those of tuberculosis but in the course of three or four months they begin to show unmistakable evidence of erosion and decalcification.

3 **Osteochondritis dissecans** Age-incidence 10–20

This is commonly the result of a vascular accident or minor injury One of two things happens either a flake of articular cartilage and underlying bone is separated by the injury and floated off its vascular bony bed by the

subsequent haematoma or alternatively some small vessel an end artery is thrombosed or embolized with the result that a small island of bone and cartilage is separated by aseptic necrosis In either case the movement of the joint may prevent the re-establishment of vascular connexions and the fragment, remaining necrotic gradually gets looser in its bed until it becomes



Fig 26 Early tuberculosis of the head of the femur

a loose body. The partially detached stage is particularly likely to set up irritation which may well arouse a suspicion of tuberculosis but a radiograph will ordinarily settle the diagnosis Fig 26 represents a radiographic appearance which is characteristic of osteochondritis dissecans But in this particular instance the condition was caused presumably by a tuberculous embolus for subsequent pictures show that this condition which began with a vascular accident has gone on to typical tuberculosis of the joint (Fig 27) One must remember then that both a central osteochondritis of the head, as in Perthes disease, and even more rarely a superficial detachment as in osteochondritis dissecans may be due to an arterial tuberculous infection The lesson to be learnt is that a diagnosis on one radiograph should be



Fig 26. Typical picture of osteochondritis dissecans.

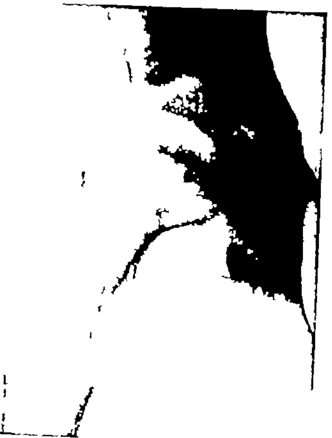


Fig 27 Same case as in Fig. 26, showing that what at first appeared to be a simple osteochondritis dissecans was in fact due to a tuberculous embolism. The typical porosis and destruction of tuberculosis are present.

regarded as provisional until it has been reviewed in the light of subsequent evidence

4 Adolescent coxa vara Age incidence 11–17

This is a traumatic displacement or gradual slipping of the head of the



FIG 28 Boy aged 14 Adiposo-genital type Began to limp on his left leg in September 1938.
The anterior view appears normal except that the epiphyseal line is somewhat broader than on the sound side The displacement is clearly shown in the lateral picture Fig 29 p. 68 (*By courtesy of Prof Waldenström*)

femur downwards and backwards off the neck (Figs 28 and 29) the latter follows a disorganization of the epiphyseal disc and its osseous relations the cause of which may be vascular infective or an endocrine imbalance There



Fig 20

is at first a reaction of the joint which may easily be mistaken for tuberculosis unless the X ray examination is thorough (see case B U p 90) It has recently been demonstrated[1] that lateral radiographs show the displacement of the head much more clearly than antero posterior views The displacement of the head relative to the neck is downwards and backwards and at first more backwards than downwards

5 Syphilis

When suggested by the family or personal history the X ray picture or any significant signs or symptoms a Wassermann test should be done a positive reaction will prove syphilitic infection but a negative is by no means decisive Again the responsibility of syphilis for the arthritis must be confirmed by the favourable effect of antisyphilitic treatment For a positive Wassermann reaction does not exclude tuberculosis especially when it is remembered that syphilitic hip disease is rare possibly more rare than tuberculous hip disease in patients infected with syphilis In the authors experience which covers many adults as well as children neither syphilitic hip disease nor combined syphilis and tuberculosis is as common as has been supposed A positive Wassermann or Sigma reaction has been returned in less than 4 per cent of the cases tested[2] Actually in adults a syphilitic hip is more likely to be taken for osteoarthritis than tuberculosis There are several forms of syphilitic joints.

(*a*) **Congenital** (i) *Epiphysitis* Age-incidence 0 to 5 Commonly associated with displacement of the epiphyses causing deformity and pseudo paralysis both being due to the displacement It occurs most often in the shoulder The appearance and radiographs are characteristic and the whole picture is different from the synovial tuberculosis of young children. It is treated by reduction of the displacement splintage and standard anti syphilitic measures

(ii) *Synovial arthritis* Age-incidence 7–12 Commonly associated with some synovial thickening and much fluid. In congenital syphilis this type is commonly symmetrical but not otherwise polyarticular

(*b*) **Acquired**

During the secondary stage some slight synovitis has occasionally been observed apparently due to synovial or perisynovial infection

The characteristic tertiary arthritis of adults is associated with gummata of the perisynovial tissues or less often of the bone ends Any of the larger joints may be affected most often the knees The areas of bone destruction are more clear cut and demonstrable than those in tuberculosis There may

[1] P D Wilson, *Journal of Bone and Joint Surgery* 20 April, 1938 p. 379 and *Surg Cl na North America* 16, 733 1936

[2] And the tests were on cases selected because they were in some way suggestive of syphilis; in 100 unselected cases at the Royal National Orthopaedic Hospital Stanmore there was only 1 positive

be periosteal thickening toward the articular ends of the bone The condition is usually accompanied by pain which is often worse at night

Syphilis may be distinguished from tuberculosis by the history by other syphilitic manifestations or scars by the characteristic night pain and when tertiary by the nodular irregularity of the perisynovial swelling and, in some cases by the characteristic radiograph The diagnosis is confirmed by the Wassermann test and by the effect of treatment

6 Haemophilia

Haemophilia leads to swelling from effusion of blood into the joint and the synovial membrane Relapses occur and the synovial membrane becomes thickened and the joint movement limited by adhesions. There is also some times periosteal new bone laid down as a result of subperiosteal haemorrhages round the articulations (Fig 30) The knee is much the most commonly affected joint Diagnosis by history clinical and radiographic examination never by arthrotomy!

7 Acute infections of the hip

(*a*) **Acute pyaemic arthritis** This is fairly commonly associated with streptococcal or staphylococcal infection and occurs occasionally in gono-coccal pneumococcal or epidemic infective disease There is a rare form of acute pyogenic arthritis in infants often associated with pathological dislocation and necrosis of the femoral head This is sometimes called Barlow's disease The onset is sudden with high fever illness local tender ness and immobility of the limb This last may be so marked a feature as to lead to a diagnosis of infantile paralysis But the localization of tenderness and resistance to movement indicate arthritis Immediate immobilization and repeated aspiration should be tried but drainage is often necessary In this and in acute arthritis the rapid onset acute tenderness and, above all the evidence obtained by aspiration distinguish the condition from tuber culosis

In children or adults a septicaemic infection of a joint commences in exactly the same way as the bacillaemic infection of tuberculosis It is commoner in children again as in tuberculosis on account of the end arteries and lack of anastomosis in areas of bone surrounded by avascular cartilage Although the method of infection is the same the reaction is remarkably different There is a rapid onset pain, high fever severe illness with the most acute tenderness of the joint A child with such a condition is terrified at the approach of a doctor for fear of any handling of the limb or movement of the joint The indication for aspiration both for diagnosis and treatment is pressing Furthermore if turbid fluid or pus is found and a pyogenic infection recognized by the bacteriologist the joint should be immobilized and aspira tion repeated daily under gas synovial fluid is at first bactericidal but when stale forms an excellent culture medium and tension within the joint leads



Fig. 30 Distortion associated with repeated haemorrhage (haemophilia).



Fig. 31 Pyogenic infection of the hip. There is absorption of the articular cartilage and erosion of the head of the femur. Note the focus in the ilium and the bone reaction above the neck of the femur which distinguishes the condition from tuberculosis.

to rupture of its walls and spreading infection of the intermuscular planes This calls for the most radical measures even amputation as a life-saving procedure

(*b*) **Gonococcal arthritis** There are several types from the acute monarticular pyogenic arthritis usually of a big joint associated with active gonorrhoea, to the chronic polyarticular arthritis which develops much later in the disease and resembles rheumatoid arthritis in that the swelling is mainly periarticular The former is as locally destructive though not as threatening to life as pyogenic staphylococcal or streptococcal arthritis the articular cartilage is quickly dissolved and ankylosis usually results Neither this type nor the rheumatoid is likely to be mistaken for tuberculosis the gonococcal fixation test is of value

(*c*) **Rheumatic arthritis** This too is much more acute than tuberculosis and almost always polyarticular and shifting It is very unlikely to be mistaken for tuberculosis On the other hand acute pyogenic arthritis may be mistaken for acute rheumatoid arthritis with disastrous results

(*d*) **Periarticular osteitis** As in tuberculosis a pyogenic infection may be deposited in a bone and spread to the joint Early recognition by pain fever and localized tenderness and extra-articular drainage will save the joint much more often than in tuberculosis. If the lesion is subacute radiography will play a valuable part in diagnosis In later stages the evidence of necrosis with a localized sequestrum which appears hypercalcified in relation to the surrounding bone suggests pyogenic infection rather than tuberculosis The sequestra are commonly a part or the whole of the head whereas in tuberculosis sequestra are more commonly seen in the juxta-epiphyseal region of the neck. In pyogenic infection there is osteogenesis in a few days and sclerosis later (see Fig 31) in tuberculosis subperiosteal new bone formation is rare and relatively faint and the sclerosis appears if at all a year or two later

8 **Rheumatoid arthritis** Age incidence is commonly 20–35 years

We are concerned with this condition in its monarticular stage, i e with the first joint affected This is most commonly the knee, occasionally the hip the wrist or the ankle As a rule the type of patient and the radiographic picture make one suspicious of its non tuberculous character (see Fig 32)

If this begins in the knee or the hip and there are no other manifestations for a time it is easily mistaken for synovial tuberculosis It should be treated under provisional diagnosis until a decision is reached either by means of a diagnostic operation or in the light of the clinical progress.

9 **Osteoarthritis** (Fig 33) Age incidence is commonly over 30.

Senile tuberculosis is sufficiently rare to be easily forgotten while osteoarthritis is common In truth it is long odds against tuberculosis being the cause of a painful hip in an elderly man but one cannot be too careful for



Fig 32. Rheumatoid arthritis. Absorption of articular cartilage and some general decalcification; no bone erosion or reaction.



Fig 33. Early osteoarthritis. Some absorption of articular cartilage no decalcification, clearly marked bone outlines with lipping An early case.

patients resent the appearance of an abscess containing tubercle bacilli in the region of the hip which they have been told is osteoarthritic and for which they have had long-continued and expensive medical treatment! The distinctive signs in tuberculosis are as follows there is limitation by muscular spasm and in the elderly generally a complete muscular fixation and the



Fig 34. Spondylitis ankylosa.

hip is silent whereas in advanced osteoarthritis there is some movement, characteristically that of straightforward flexion and extension with rotation or abduction and there is often an audible creak or grate as of bone on bone at a certain angle or angles The radiograph of tuberculosis shows erosion and decalcification irrespective of weight-bearing whereas in arthritis there is disappearance of articular cartilage and the approximation of bone to bone at the weight bearing area with surrounding lipping or mushrooming of the head and an absence of decalcification

10 The ankylosing arthritis of the hip associated with Spondylitis Rhizomelique (see Fig 34) Age incidence is 15–30 Sex—male

Sometimes the earliest indications of this disease are pain and limitation of movement in one hip which at first sight suggest tuberculosis A failure

to make the distinction is all the more unfortunate in that the patient may find to his extreme annoyance after prolonged treatment on a frame for tuberculosis of one hip that his spine and both hips are ankylosed!

The appearance of these patients is as a rule rather characteristic, thin, sallow and dark haired Though this appearance is toxic it is usually quite different from that of tuberculosis Skiagrams show that the articular cartilage is being destroyed rather than the bone It is as if the articular cartilage with its underlying bony shell is being uniformly dissolved Actually it is this solution which prepares the way for the rather rapid and solid ankylosis As a rule the sacro iliac joints are attacked quite insidiously without pain before any other joint and radiographic examination of the sacro iliac joints indicate a remarkably symmetrical replacement of the sacro-iliac cartilage space by bone, with the areas affected spotted or patchy This is most distinctive and valuable evidence (see Fig 81)

11 Neoplasms

The symptoms and clinical signs of a sarcoma or a secondary carcinoma may closely simulate those of tuberculosis Fortunately they can almost always be distinguished from tuberculosis by radiographs though a massive pyogenic osteitis of the ilium may look exactly like a sarcoma A benign growth or cyst is usually far more clear-cut out of normal bone than a tuberculous focus but may be as Fig 35 illustrates a very deceptive lesion

12 Hysteria

Here the appearance of the patient the history of onset the reaction to examination and the other familiar signs of hysteria are likely to point to the correct diagnosis The X ray appearances are normal At the same time difficulty may arise and the distinction may become one of clinical judgement and negative radiographs. It is however important to remember that examination under an anaesthetic is only justifiable if radiographs are normal and the clinical signs of tuberculosis absent

13 Various

Not long ago one of the authors saw a patient with a very painful left hip The signs of arthritis were present but history and examination suggested and radiographs confirmed the existence of old unreduced congenital dislocation of the hip It was rather naturally assumed that the condition was arthritis due to mechanical overstrain but at operation tuberculous pus was found in and round the hip-joint!

TREATMENT

General

This is standard For in every case of tuberculosis of the hip in a child we must assume a persistent active and dangerous tuberculosis of the lymph glands With rare exceptions this is equally true for adults and unhappily

with far graver significance The exceptions are those with a very long history perhaps twenty years or more of pain and strain in whom mechanical strain on an unsoundly healed joint lesion has kept up grumbling disease long after the primary lymphatic tuberculosis has finally healed In these



Fig 35. Malignant disease in a woman of 52. The condition simulated tuberculosis in history and all signs and symptoms. Distinguished by radiography The patient died with multiple metastases within three months. Contrast appearance of chronic osteomyelitis of ilium shown in Fig 20 In this the joint has not been crossed.

cases we have the visible lesion alone to consider with its eradication or healing they are cured

The aim of general treatment is the complete and permanent recovery of the patient as a whole and this general treatment should be carried out in an open air hospital with sun and air skilfully applied summer and winter for at least a year in every case irrespective of what is done for the joint In children the hospitalization of hip disease is likely to last three years or longer Afterwards and this after-care is even more important (and more difficult) in adults than in children the patient must live under really good conditions for several years This does not in the least mean that the child cannot go to school or the man to work Mention has already been made of the value

of occupation for the mind and the hands of all the patients while in hospital indeed no time should be lost before directing a man's mind toward some new vocation when his old is obviously unsuitable and preparing him for it as far as possible

Local

On admission the patient is ill and though perhaps imperceptibly going down hill the bacilli are multiplying the tuberculous infiltration of the cancellous bone is advancing and the sensitive joint is guarded by the spasm of its wasting muscles. But the protection of muscular spasm is far less effective than splintage, for one thing, the spasm itself increases the pressure on the weakened bone and softened cartilage, for another the pull is unbalanced and deformity results and in sleep the slackening of the muscular control allows movement Nature's cure of hip disease leaves a flexed adducted shortened, and wasted limb

In a few weeks as a result of rest comfort and good food obvious illness disappears pain fear of movement muscular spasm deformity and destruction are checked by perfect immobilization and the wasting of bone and muscle is lessened by the unrestricted circulation and by the effect of the sun and the wind on the skin Complete physical rest is the essential foundation of treatment throughout this stage and ambulatory splintage is utterly wrong

The hip is an elusive joint with a socket set deep in the pelvis allowing movement in every direction and controlled by the strongest muscles of the body a part notoriously difficult to splint Thomas taught us to avoid all risk of constricting the circulation and that rest included relief from pressure in the joint as well as from movement whilst experience teaches us that it is wise to keep the pelvis under daily observation The joint is sensitive and the muscles are irritable but it is essential that the parts should be kept in the chosen posture controlled but uncompressed Fixed extension on a well padded frame fulfils these aims

Splintage

The splint must be comfortable with a smooth clean surface for it is to be semi permanent in the sense that from month to month there should be no movement involved by nursing no lifting of body or limbs no washing of the parts that cannot be reached without disturbance The whole trunk must lie straight and square with the pelvis, and the splint must enable us to place the affected limb in the position of choice It is also desirable that the splint should be cheap, simple, of a standard pattern and easy for nursing

For the sake of simplicity only one type of frame will be described in this book the principles can be applied to any other (see p 301)

On the frame the body itself must always lie straight and every day the patient's nurse must assure herself that the anterior superior spines of the ilia are exactly level If this is not done it is only too likely that scoliosis will

result With the body then perfectly true on the frame the limb can be placed and permanently held in the exact position of choice This position varies somewhat according to the age of the patient and the prospects of the joint

Whenever mobility is our aim we obey the rule for the posture of any joint where movement is expected and put the limb, not in the anatomical position but rather toward that which is difficult to attain after immobilization, whether the difficulty is due to weak and overbalanced muscles or to leverage and gravity

The Primary position of splintage. For the hip the standard position is

1 Abduction of about 30
2 Flexion of about 3
3 Rotation nil

The prospect of ankylosis must be accompanied by a change in the position of splintage from the Primary to the Final

The Final position. The optimum position for final ankylosis is

1 Abduction 0–5 ✓
2 Rotation slight external 5–10 ✓
   This external rotation in ankylosis is advantageous in order that when the patient swings his pelvis round to take a step forward the foot shall point forwards rather than a little inwards.
3 Flexion up to 10 years 10 15 years, 15 20 years 25 30 years, 30–35° or say a degree for each year of the age up to 30.

Figs. 36*a* and 36*b* and Figs 37*a* and 37*b* are photographs of two cases with fixed hips illustrating the effect of the different angles of flexion. For adults *30 to 35 is probably the wisest compromise between the best position for* standing or walking and the best for sitting The flexion angle varies with the age because during childhood the lumbar spine can develop unusual mobility and so allow the patient to sit comfortably with hip only slightly flexed but later in life the spine is not nearly so adaptable though what it has learnt in youth it will keep for many years The patient s occupation must also be *remembered and where much sitting is expected* with little standing or walking a degree of flexion up to 45 may be desirable an angle which is right for the sempstress is wrong for the station master

There is another difficulty for the muscles of a joint, once free movement has been lost no longer work in balance As a result of this unbalanced force the position of the joint alters imperceptibly during the process of ankylosis *and even after the most solid* ankylosis if the epiphyseal cartilage is intact and growing The position desired for final ankylosis is known what allowances are to be made ? For the present discussion it is assumed that operative arthrodesis is not in view Without arthrodesis it will inevitably be years before the joint has settled soundly into its final position and once the

dominant immobilization of the frame is changed for less effective splintage the overpowering pull of the flexors and adductors will insidiously deform the joint





Fig 36a Fig 36b
Girl aged 16 Flexion angle [illegible] She stood with considerable lordosis Sat easily

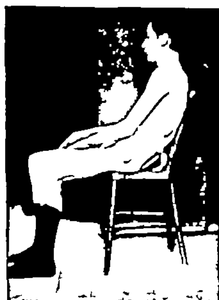




Fig 37a Fig 37b
Boy aged 17 Flexion angle 11 He stands easily but sits with difficulty

It is wise then to pose the joint without rotation and with more abduction and less flexion than that required in the end. In young children we should anticipate and allow for very gradual adduction and flexion beginning after the full control of the frame has been lost The younger the patient

the wider should be the abduction, for sound fixation is attained so much more slowly The bearing of extra-articular arthrodesis will be discussed later

We have then *a standard treatment for the active stage*

1 *For the body as a whole*, the prompt application of physical rest and physiological stimulation and
2 *For the hip* fixed extension and unremitted immobilization in a chosen position

In children (except in those rare instances when radiographs show a metaphyseal focus which is clearly *extra articular) there is no indication at an early stage for operation*, whether directed towards diagnosis towards eradication of the disease or the attainment of synostosis But in adults the problem is altered owing to the difference in the patient s power of reaction to or recovery from the disease. Furthermore, the time factor is different children can spare a long time if it is in their best interest, as undoubtedly it is, adults seldom have unlimited time, nor do they benefit from prolonged splintage in bed (rather the reverse) For adults, then, there is a definite advantage in a relatively early diagnosis and in operative arthrodesis with or without thorough eradication of the disease

Correction of deformity

When a patient reaches hospital in the active stage of the disease there is always some flexion deformity

Radiographs will show whether this is due solely or mainly to muscular *spasm or associated with advanced destruction of bone.*

1 If the deformity is purely muscular most of it can be corrected with one steady slow movement carried out without an anaesthetic as the final act of applying the frame *This movement must be followed always and instantly by complete immobilization* Some lordosis will persist for a day or two until the flexion of the hip is fully lost.

2 But if the case reaches hospital later and radiographs while showing that the deformity is associated with bone destruction, yet do not suggest organized fixation the patient should be anaesthetized and put on the frame During the whole of the procedure the hip must be most carefully held for the anaesthetic will have thrown its muscles off their guard. When all is ready the surgeon tries to reduce the deformity slowly steadily, in the way just described without wrench or jar

If gentle pressure fails to correct the deformity, or if the radiographs indicate commencing organization, it is best to immobilize the joint with fixed traction, adjusting the limb at an angle rather more obtuse than that of the flexion, so as to induce considerable lordosis. It will generally prove possible to improve the position from time to time as the traction and immobility relieve the muscular spasm and lessen the infiltration lordosis will diminish and the angle of the frame can be progressively altered.

At a still later stage, if the organization has advanced towards healing and

there is fixed adduction as well as flexion, correction cannot be carried out by conservative means Such a case no longer belongs to the first stage but to the second stage (ankylosis group) It will be put in plaster without altering the deformity until correction by osteotomy is safe

Cases of deformity seen only when healing is complete will be considered later

Second stage

While the first stage is associated with active disease and the third with the signs of healing the second is transitional By this time the patient has responded to treatment pallor has gone fever is over his body is revitalized and resistant necrosis and decalcification are now at a standstill the joint and its muscles are no longer irritable.

It is necessary to note the signs which indicate the beginning of the second stage A time period is helpful yet as there are many variable factors it can not be precise since it must be related to the clinical progress in each case So long as the patient remains feverish ill and is losing weight it would be futile to begin to count the weeks The beginning of *the second stage may be put at three months after all the following conditions have been fulfilled*

1 Fever, if present, has disappeared
2. Progressive loss of weight has changed to gain
3 An aspect of illness has changed to one of health

At the end of this three-month period which may be four eight or even twelve months from admission the joint will no longer be tender or swollen

This then is the beginning of the second stage Up to the present every effort has been concentrated on the improvement of general health and vitality and the checking of inflammation in the joint At this point however we must so far as children are concerned face a critical decision and to settle it wisely we must review and sum up every aspect of the case taking into account age health social conditions employment (or prospective employment) and the amount of damage done to the joint *This question does not arise in adults* in whom a hip-joint proved to be tuberculous is only safe when ankylosed or amputated.

Are we to aim at a movable or a fixed hip? This question is to be answered for each child in strict relation to our standard, a permanently safe and useful limb (Lovett) Having come to a decision we must at once take steps to achieve one or other aim and these steps diverge in that the treatment favourable to mobility is unfavourable to fixation and vice versa. Both these aims are legitimate but it is easy to fall between two stools and end with either movement that is not free enough in its range and firm at its limits to be safe or fixation that is not massive enough to resist strain. For if the movement is not quite free over its whole range (whatever that may be) a sudden jar may overcome the muscles and rupture the granuloma Tubercle bacilli may thus be set free in damaged tissues—a state of affairs likely to lead to recrudescence of the disease

Sometimes this happens again and again Figs 51 and 52 illustrate typical examples of this insecure healing with persistent recurrence over a long period of years

So too ankylosis whether involving the whole or only part of the co-apted surfaces is never safe until it is sound, for unsoundness means that the bone or fibrous tissue forming the union is immature or still inflamed and therefore unfit to stand the wear and tear of use

A partial ankylosis however sound, may not for a time be massive enough

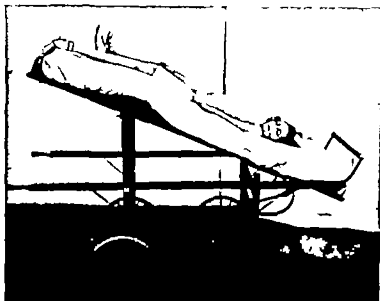


FIG 38. Carshalton Traction.

to resist a shock. For such conditions extra-articular arthrodesis provides a happy solution.

If then the joint surfaces do not appear much damaged or deformed as shown in the radiograph, and this is borne out by free movement through the very small range which is all that one tries at this stage, *mobility* can be our aim But in some cases the issue is not clear the prospects of mobility are still uncertain, and the final decision has to be held over for a *test period* of weight extension e g Carshalton (Fig 38) If the movement of the joint gets freer week by week, we may safely go on with the weight and pulley, aiming at a mobile joint. We aim at mobility so long as there is good hope of getting movement sufficiently well supported at its limits to be safe *We aim at ankylosis only when radiographs or tests tell us that without ankylosis the limb is unlikely to become permanently safe and useful.*

It is well to remember the unique difficulties of the hip The erect position has its drawbacks for our weight-bearing joints are prone to osteoarthritis The hip is affected most often and most painfully While at every step the knee

and ankle have to carry the weight of the body the hip labours under so great a mechanical disadvantage that it must bear twice that burden It is small wonder that this overworked joint even when perfectly formed by Nature is a common seat of osteoarthritis Secondary arthritis is still more common ultimately inevitable after arthroplasty when the bone ends have been imperfectly reshaped and relined by the surgeon or have suffered in form though not in lining by coxa vara and pseudocoxalgia How poor then must be the ultimate prospect for a joint when the articulating parts are deformed by the erosion of tuberculous disease Natural healing is seldom of a sort which will make the best of a bad job and the surgeon often feels called upon to interfere In making his plans he should remember that sound fixation is better in the long run than a semi mobile but ill fitting weight bearing joint At the same time he will recognize degrees of damage and must decide when it is safe and right to aim at mobility and when such a course will leave the hip prone to a recurrence of tuberculosis or an early onset of disabling osteoarthritis

The aim is mobility

Experience has taught us that this is never a sound policy in adults and only in a minority of children In these the surgeon will rightly avoid a premature decision therefore whenever there seems a reasonable hope of ultimate mobility he will immobilize by some form of traction splintage in decubitus during the second stage More haste less speed should be our guide The earlier longer and better the immobilization the better is the prospect of movement

In every case then in which there is radiographic evidence of destruction of the articular surface of the femoral head or the acetabulum, the possibility of attaining a useful, permanently safe, and painless range of movement must be reviewed from time to time If after recalcification, there is good ground for hesitation it is probable that arthrodesis will be the best policy Fortunately a hip arthrodesed in childhood is wonderfully serviceable and not very noticeable And nowadays the surgeon gleaning the fruit of much experience of operative arthrodesis in many clinics will have little difficulty in making sure of sound ankylosis in good position The indications for and technique of arthrodesis will be considered later

The aim is ankylosis

Here one must consider children and adults separately *In children* so the authors believed it is always best to carry on with treatment on a frame until the general condition has been very good for many months and X rays show evidence of healing by recalcification and better definition of outlines This is the time for a decision for or against arthrodesis and if the latter is to be carried out for a choice of the technique which will be most suitable Often extra-articular arthrodesis alone will suffice But where there is a mass of debris (see Fig 30) showing no sign of consolidation, and separating

what is left of the femoral head and neck from the ilium it may be advisable to excise first and only at a second session to carry out extra-articular arthrodesis

In performing high extra articular arthrodesis the authors believed strongly in the advantage of *operating on the patient lying undisturbed on the frame or through a window in the plaster* and such is their practice For this imposes no strain on the infected granulation tissue and who can tell how securely it is



FIG 39 The femur and roof of the acetabulum are separated by a transparent area representing a mass of debris, sloughed cartilage perhaps pus, and granuloma, sufficient to render any attempt at extra-articular arthrodesis unwise.

healed? After the operation the patient remains on the frame until X rays show that he can be got up in plaster The plaster is retained until the synostosis is sound The greatest care must be taken to avoid any movement while the plaster is being changed

The authors have recommended operative arthrodesis as an almost routine treatment. But all are not agreed as to the advisability of this course and there can be no doubt that it is only advisable with expert surgery in a first-class orthopaedic hospital The surgeon should be prepared to overcome technical difficulties in order to maintain the splintage undisturbed

It will be noted later that in regard to most tuberculous joints a minimum age for arthrodesis is suggested, but not so for extra articular arthrodesis of the hip This is on account of the great shortening and atrophy of the limb that follows prolonged disuse in the hip

A child with a tuberculous knee or ankle can get about well on a caliper

or walking Thomas knee-splint but no ambulatory splint other than a hip plaster (Fig 42) will protect a tuberculous hip. This is so cumbersome that it is often advisable to do an extra articular arthrodesis at an early age Arthrodesis in young children will bring about an internal immobilization fully strong enough to protect the granuloma from all the strains of wear and tear and thus lead to its sound healing, but will not always resist the forces of growth under the abnormal circumstances Bone grafts when fully colonized are alive and therefore plastic to great force continuously and very gradually applied however resistant to sudden jars It may indeed be necessary owing to the slow development of secondary deformity to do a low transtrochanteric osteotomy later on But the more natural development and growth of the limb associated with the early return of function is of the greatest value and more than discounts the disadvantage of a possible second operation

Continued conservative care for fixation

There comes a time when the patient can with safety be transferred from bed and a frame to plaster with a view to getting up There then begins a duel between skill and deformity Well moulded close fitting plasters will do much[1] but if anyone is confident of his powers of holding a hip in a single spica and would put them to the test let him choose a lean and placid child with prominent bony points

Flexion is fairly easily controlled in the long plaster but adduction is not mastered without a close hold of the opposite tuber ischii, for this side of the pelvis cannot be held up by its anterior superior iliac spine alone if the good hip is left free to flex. For in flexion the tensor fasciae femoris and sartorius bear upon the edge of the plaster just below the anterior superior spine as the movement proceeds further the flexing thigh pushes that side of the plaster forwards and upwards, and levers that side of the pelvis down. This tends to adduct the affected hip since it forces the good side of the pelvis downwards in relation to the limb in plaster bringing the origin of the adductors nearer to their insertion the process is repeated day after day the plastic tissue in the hip yielding little by little The movement is slow and very persistent it does not show much on hospital records since as a rule it only becomes obvious long after the patient has left hospital. But it is responsible for many cases of late adduction deformity with additional and unnecessary practical shortening Figs 40 and 41 illustrate this point It is possible to prevent this adduction within the plaster by a *perineal strap* bearing on the tuberosity either as a firmly applied, well felted strip of plaster or a padded leather groin strap fixed to studs in the plaster (and the former is more positive) but either is difficult to nurse even in bed and still more so when the patient gets up This method though valuable in special cases and used a good deal at Oxford, can hardly become standard.

[1] See the excellent monograph by Calvé and Galland, *Les Appareils Plâtrés* Paris.

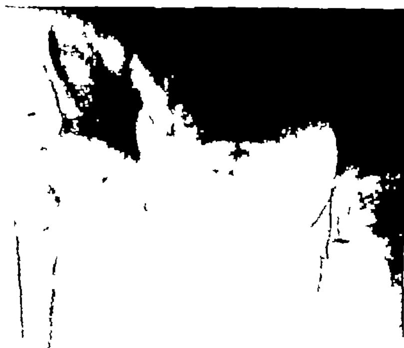


Fig 40 Girl aged 7 Tuberculous hip treated in single long spica plaster (Radiograph, May 1921).



Fig 41 Same case October 1924—Note adduction deformity!

The safest plan is to include the upper half of the good thigh the plaster can then be moulded round the tuber ischii and under the anterior superior spine This hold is safe for flexion of the good hip with its leverage action is prevented (see Fig 4?)

At a still later stage in an arthrodesed or ankylosing hip, less complete control is allowable since the adductors and flexors have been well stretched and the organizing fibrous or bony tissues are becoming sound and better able to resist a strain

By intelligent anticipation we distinguish those cases in which the healing will long remain unsound The younger the patient the less closely adapted the raw surfaces, and the greater the extent of unhealthy bone, the slower will be the achievement of any form of ankylosis In some cases it may take four or five years In such the original frame position should be one of fairly wide abduction and the first plasters should hold this position Then through the long convalescence the less perfect hold of the single long spica is sufficient In these young children even after the fixation is firm enough to answer Thomas s tests of soundness there is likely to be a little, very slow, insidious movement of flexion and adduction which will bring the limb into the position of choice But too much abduction is a mistake for the gain in practical length is more than countered by the strain on the back and the risk of progressive secondary scoliosis



Fig 4 Extensi e plaster giving complete immobilization of the hip

Third stage

This is the stage of constructive organization of bone and fibrous tissue of increasing movement or firmer fixation.

I **Mobile group** Provided that repeated tests show that the range of movement is increasing rather than diminishing the patient may be passed safely through the following programme —

(a) *Extensions and splints* are removed, and the range of movement measured and recorded. Complete freedom in bed is allowed, and the movements of the affected joint are tested every few days Thomas taught that a joint was improving so long as its range of movement was increasing, and that it was cured when no reduction of its range of movement could be discovered on repeated examination after it had been set completely free

(b) *Patten and crutches* If the range of movement is found to be

progressively increasing after a fortnight's freedom the patient is allowed up on crutches with a 4-inch patten on the good leg The range of movement is noted each week then, if all is well each fortnight for three to six months.

(c) *Crutches* After these if radiographic and clinical verdicts are favourable the patient may wear a boot without a patten for an hour or two in the morning If the tests continue to be satisfactory the patient is allowed to leave the patten off more and more then altogether

(d) *Sticks* Later, sticks replace the crutches

(e) *Supervision* Finally supervision both general and local, monthly, for a year or two, then less often.

A word of caution must be added. Some children are so active that they cannot be allowed so much freedom For a time a single Thomas splint may be added to the patten and crutches to be worn during the day and left off at night

II Ankylosis group It has already been stated (p 40) that once fixation is inevitable or desirable operative arthrodesis is the rule in the author's practice But this is by no means universal and the following is an alternative programme

(a) Frame and plaster in bed.
(b) Plaster patten, and crutches
(c) Plaster and crutches.

At each change of plaster the position of the joint is recorded radiographically and by noting the flexion deformity if any and the relation of actual to practical measurements As soon as the patten is removed the patient begins to bear weight on the limb at first only a little using crutches then more and more provided that no discomfort or hint of harm is evident

At some time in the convalescent period it becomes clear that the union (fibrous or bony) between femur and pelvis is sound the tendency to deformity is over but the bone still needs protection from sudden strain or injury At this point the plaster can be replaced by a single Thomas splint adapted to take lateral bearings on trunk pelvis and internal femoral condyle or the short spica continued till ankylosis is considered sound—then freedom is allowed under frequent observation

The convalescent stage ends when the healing is sound and strong as shown by stability of position after splints have been omitted (Thomas's secondary diagnosis of restoration)[1] Additional proof is given by the appearance in the radiographs of stratification of the bone in accordance with the demands of the altered anatomy The osteoblasts, now long relieved from the depression and distraction of the toxins of the tubercle bacilli have been able to respond to the stimulating strain of returning function and to rearrange the trabeculation in accordance with new lines of force (Fig 43)

[1] See p. 39



FIG 43 Ilio-femoral arthrodesis which has been followed by sound bony ankylosis across the joint

SUMMARY OF SPLINTAGE

(1) Active stage	Complete immobilization with fixed extension (e.g Jones Abduction Frame)
(2) Second stage	
(a) For mobility	Traction without complete immobilization (e.g the Marsh Extension)
(b) For fixation	Immobilization without extension (plaster of Paris) Extra-articular arthrodesis.
(3) Convalescent stage	
(a) For mobility	Joint free no weight bearing at first (patten and crutches, with single Thomas exceptionally)
(b) For fixation	First immobilization and weight bearing (plaster of Paris) Less protection and weight bearing (reduced plaster or modified single Thomas).

Methods of splintage proved by long service have been chosen to illustrate the plan. Other splints may be used instead [1] Those described are durable

[1] For Carshalton method see: Traction by Suspension in the Treatment of Tuberculosis of the Hip-joint *Annual Report of the Metropolitan Asylums Board*, 1926/7 p 361

and inexpensive they can be made quickly without costly machinery they do not require repeated fittings and are not soon outgrown Being of standard pattern, their manufacture fit and use are thoroughly understood by all concerned.

OPERATIONS

(I) Diagnostic

Indications

In children diagnostic operations have in the past seldom been carried out for as a rule provisional diagnosis (plus treatment) answers all requirements until clinical progress and a series of radiographs have made the diagnosis clear However the safety of the diagnostic removal of a gland may bring *the advantages of positive information at an earlier stage within reach without* the disadvantages and risks of arthropsy

In adults on the other hand whenever there is uncertainty a diagnostic operation should be considered

(*a*) **The removal of a regional (iliac) gland** This is a recent introduction and apparently gives as reliable information as arthropsy If this is proved after a longer trial it is as a minor operation free from the risks incurred by arthropsy (see p 22) very much to be preferred and is the diagnostic operation of choice

(*b*) **Arthropsy** (for adults) The inspection of the joint and removal of synovia or debris for bacteriological examination This operation is postponed until the patient is fit for arthrodesis. The exposure of the hip will if the naked-eye appearances are characteristic of tuberculosis be the first step of an intra-articular arthrodesis

The operation is done with the patient undisturbed on his frame

N.B The pathologist wants all the tissue we can safely give him especially in doubtful cases with indeterminate naked-eye appearances i e just the cases in which we need his help most *Give him* if you can find it *fluid for* smears cultures and guinea pigs and synovial membrane for histological and bacteriological examination He may have to examine sections from several different parts before finding tubercle bacilli or characteristic histological appearances (see p 26)

The following is a good example of the value of diagnostic arthrotomy in a doubtful case even in a child

Case B U

13.xii.33 A girl of 13 was sent to one of us with a diagnosis of tuberculosis of the hip. She had been confined to bed for some months. The history was fairly typical She looked well, her left hip exhibited 75 per cent limitation of movement in all directions, apparently due to muscular spasm. X ray (*Fig* 44) Admitted to hospital. Signs of severe arthritis persisted so on

9.11.34 *Diagnostic arthrotomy* Anterior Smith Petersen incision thorough exposure of the front of the capsule This appeared thickened and rather red; it was opened (very tough to cut through) Immediately a discoloured prominence presented itself in front of the neck from which protruded three very sharp needle like points. These bony spicules must have pricked the synovial membrane on movement The whole bony prominence was removed and the wound closed



Fig 44 Case B U

The arthrotomy completely disposed of the diagnosis of tuberculosis. This was a case of coxa vara adolescens with the most unusual feature of persistent and severe symptoms and signs of arthritis. Had a lateral view been taken the diagnosis would have been obvious; but without the removal of the spicules the source of pain and the synovial irritation would have persisted

The long period of rest had stabilized the position and the patient did well, though some limitation of internal rotation remained. She was last seen in 1945 when she had done two years nursing and was getting some aching in her back due to an old osteo chondrosis of the 6th dorsal vertebra. She made no complaint of the hip, but her left lower limb was ½ inch short; movement was free and painless, but X rays showed some mushrooming of the femoral head.

II OPERATIONS FOR ARTHRODESIS WITH OR WITHOUT ERADICATION OF DISEASED TISSUES AND DEBRIS

Extra articular arthrodesis Intra articular arthrodesis

In this book the word excision implies excision and intra articular arthrodesis the term wide excision is used whenever pseudarthrosis is the aim In the opinion of the authors *excision* should be carried out whenever



FIG 43. Ischio-femoral arthrodesis done by the posterior open operation. (Foley)

the focus is so extensive or so active that it is likely to interfere with the stability or with the success of extra-articular arthrodesis alone. For example in an adult over 30 the disease commonly persists in spite of immobilization whether by splintage or by extra-articular arthrodesi And persistent active disease i likely to lead to the failure of the ordinary methods of ilio-femoral extra-articular arthrodesis through absorption of the middle of the graft where it is close to the disease and where the strain imposed upon it is greatest for these two points u ually coincide

These remarks particularly refer to *high arthrodesis* i e ilio femoral arthrodesis When this takes the form of a flying buttress the extra articular synostosis cannot be relied upon to carry all the strains of function Ordinarily an ilio femoral arthrodesis relies for lateral strains (abduction and adduction) upon a reasonably fixed point in the region of the acetabulum and the



FIG 46 Ischio-femoral arthrodesis by the closed method. (Brittain)

stability in the end resembles that of three-point suspension with the other two points represented by a broad flat synosteal bridge between ilium and great trochanter resisting antero posterior movement

High extra articular arthrodesis then may call for previous excision of the joint to provide additional stability On the other hand the later methods of low *extra-articular arthrodesis* would appear to be less dependent on intra articular stability and in its strongest form the union should be strong enough to take all the stress of function, without any strain reaching the joint

Since the introduction of ischio femoral arthrodesis (Brittain)[1] ten years

[1] *Brit. J Surg* 29 93–104 1941–2

ago the operation has proved successful in that it not only produces good sound ankylosis but at the same time permits deformity to b corrected. Trumble's operation on the other hand has the great di advantage of not allowing correction of deformity

High arthrodesis

Conditions favourable to high arthrodesis are

1 A reasonably fixed point between what is left of the head of the fem and what is left of the acetabulum
2. Healthy bone in the ilium above the acetabulum and in and around th great trochanter



FIG. 4 *a*, *b*, *c*. Ilio-femoral arthrodesis with graft turned down from ilium and fixed into the trochanter with a bone peg. Note hypertrophy of the graft and subsequent ankylosis of the joint. (*British Medical Journal*)

Unfavourable

1 The presence of a cold abscess in the area to be occupied by the graft A sinus in this region is a contra indication.
2 Extensive femoral or iliac disease

Methods (*a*) *Children* The authors have found that the most reliabl method in children is that associated with Wilson [1] a very large flap of bone is turned down from the wing of the ilium and inserted into a deep cleft between the trochanter and the neck or in the trochanter

Technique A Smith Petersen incision is carried far back. Almost the whole

[1] J C Wilson, *Journal of Bone and Joint Surgery* 1933 15, 22

wing of the ilium is exposed just extraperiosteally but care is taken not to open the joint The front of the base of the great trochanter is exposed and a saw or chisel cut made downwards and outwards from the digital fossa is levered open so that the great trochanter leans away from the neck leaving a cleft in the bone between their bases (Fig 48) Then taking a very fine chisel about ¾ inch wide the iliac flap is outlined starting at the anterior inferior iliac spine passing vertically upwards then backwards ½ inch from the crest to a point as far back as can be reached This chisel cut is then brought down wards and slightly forwards to a level about ½ inch above the acetabulum Sometimes one sometimes both tables are taken depending upon the stout ness of the iliac wing It is often helpful to use a number of curved chisels and to leave several in place while the others are being driven in to indicate the general outline of the flap and by combined tentative leverage from time to time to ascertain when the bone flap is ready to be lifted and turned down (Fig 48)

When the flap is free and only held by its base it is clasped by two pairs of bone-holding forceps and lifted outwards then gradually coaxed down deeply into the cleft at the base of the great trochanter It is generally advisable to reinforce the upper spring of the bridge and sometimes also the lower by packing some additional biggish flakes of bone from the ilium into the hinge of the flap above and sometimes also round its insertion below The Smith Petersen incision is then closed in the ordinary way

N.B This operation as all other constructive hip operations is done through a window in a plaster spica or with the patient undisturbed on a Robert Jones frame In the latter case after the operation a spica bandage is put on round the frame with plenty of wool over the dressing

(b) *Adults* In adults this flap from the iliac wing does not work well because the rigid adult bone breaks off completely Good results are obtain able much more easily by using a sliding iliac graft about 1½ inches wide taken from just behind the anterior superior spine This is quicker and requires far less exposure

The ilio diaphyseal graft (Berck) This method of grafting initiated by Richard at Berck Plage is applicable to cases unsuitable for the technique just described on account of disease in the great trochanter The exposure is the same except that the separation of the glutei is carried much farther down, so that the diaphysis of the femur below the diseased area is exposed A *thick* osteoperiosteal graft is then raised from the tibia in one piece and of sufficient length for one end to be imbedded in the ilium above the aceta bulum and the other in the femur well below the great trochanter These thick osteoperiosteal grafts come off the tibia in a curve with the periosteum on the concave side this curve is left undisturbed and the graft is inserted with the periosteal surface deep and is found to fit admirably into place

Initially such a graft is very weak indeed This method depends for its success on accurate and long-continued protection.

Tendinous origin of Gluteus medius

Periosteum reflected with Glutei

Gluteus medius

Gluteus minimus

ILIUM (Flap of outer cortex)

Origin of Tensor fasciae latae

Anterior superior spine of Ilium

Sartorius

Capsule

Rectus femoris

Tensor fasciae latae

Great Trochanter & cleft in femur

Vastus lateralis & medialis

Reflected skin & fascia

Tendinous origin of Gluteus medius

Gluteus medius

Gluteus minimus

ILIUM (Inner cortex)

ILIAC FLAP

Origin of Tensor fasciae latae

Anterior superior spine of Ilium

Sartorius

Capsule

Rectus femoris

Tensor fasciae latae

Flap of outer cortex reflected & inserted into Femoral cleft

Vastus lateralis & medialis

Fig 48 Illustrates two successive stages in the iliac flap extra-articular arthrodesis.

Low arthrodesis Ischio femoral synostosis

In the opinion of the authors a number of cases which would formerly have necessitated amputation or wide excision will in future be treated successfully by low arthrodesis

(a) **Trumble's operation**[1] (see Table 2) This consists in using a specially shaped tibial graft to bridge from the ischium to the shaft of the femur The approach is of course posterior (Fig 49) He uses the standard approach to the sciatic nerve under the gluteus maximus by reflecting the muscle from its insertion Fig 50 illustrates the X ray appearance one month after the operation and five years later

TABLE 2

Case no	Sex and age	Date of operation	State November 1937		
			General health	*Hip-joint*	*Graft*
9	M [illegible]	4 vi.36	Well except for some pain in Lt elbow TB *Alfred*	Firmly fixed Painless.	Very long graft Firmly united No hypertrophy but no absorption
10	F 19	1[illegible].viii.36	Well (July 1937)	Firmly fixed. Painless.	Firmly united Hypertrophied. (X ray April 1937)
11	F 22	(1) 18.xii.36 ( ) 12.1.37 Graft elevated from nerve	Excellent Some numbness in foot No pain.	Still some pain in hip on walking much less than before Sinus still discharging Hip fixed firmly	Very short graft Strongly united, and hypertrophied.
12	F 17	23 v.37	Died 28 viii.37 Acute renal infection complicating stone	I M Firmly fixed by graft.	Firmly united at both ends. No sign of absorption of body of graft

Mr Trumble was kind enough to reply to a letter asking for further information as to the results of his operation, and to send the above Table

I have had four additional cases since The main features are shown in the enclosed table One patient died about three months after operation with an acute infection of the kidneys. The hip region was removed at post mortem examination. Everything was in order the graft being firmly fused with the femur and ischium. Immediately after operation in Case 11 paralysis of the sciatic nerve appeared with pain in the foot. I had to reopen the wound and elevate the graft which was pressing on the nerve In this case gross destruction and deformity at the hip-joint had resulted in close approximation of the femoral shaft to the ischium, and in inserting the graft I had not left sufficient space for the nerve. After the second operation the trouble cleared up except for a little numbness in the foot and the graft has fused well.

(b) **Brittain's operation**[2] This differs altogether from Trumble's in that a typical bifurcation subtrochanteric osteotomy is done and the upper end

[1] Trumble reported this operation in two papers: *The Australian and New Zealand Journal of Surgery* March 193[illegible]; and *The British Journal of Surgery* 1937 p 728

[2] Personal communication.

of the lower fragment is inserted into a pit dug in the ischium below the acetabulum Recently Brittain has used a strong tibial graft to reinforce the ischio-femoral attachment He describes his operation as follows

The patient is placed on his side the hip to be operated on being uppermost

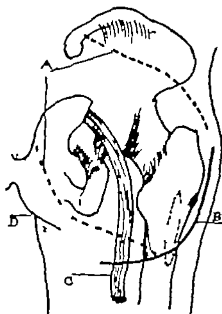
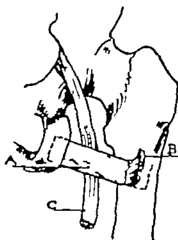


Fig 49 *a* Showing line of incision and how it skirts the insertion of the gluteus maximus into the fascia lata above and the femur below and crosses the middle line of the thigh below the level of the gluteal sulcus. The limits of the gluteus maximus are represented by the broken line the osseous insertion by the area enclosed in the interrupted line on the femoral shaft. A. Outline of gluteus maximus; B Line of incision; C. Sciatic nerve; D Gluteal sulcus.



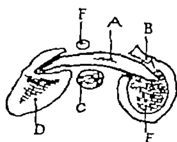


Fig 49 *b* Diagrammatic representation of horizontal section through the graft in position, showing how it arches over the great sciatic nerve and the manner in which the ends are cut to a wedge shape to facilitate introduction. Both ends are firmly gripped and cannot get out of position The trap-door in the femur is shown replaced. The sciatic nerves are shown separated by the graft. A Graft B Trap-door closed; C Great sciatic nerve; D Ischial tuberosity; E. Femur; F Lesser sciatic nerve

The patient is supported either by sandbags or by a special hip-rest A bone graft 4 to 6 inches in length is taken from the tibia This should include the crest of the tibia and it will be necessary to raise the muscles from the medial

aspect of the bone A 4 inch incision is made over the lateral aspect of the great trochanter starting at the tip and proceeding downwards The incision is carried down to bone and elevators inserted A subtrochanteric osteotomy is now carried out at a site previously decided upon A special chisel with a square-ended handle is then inserted through the divided bone and this is kept in the coronal plane until it abuts against the ischium It is then gently hammered inwards for a distance of half an inch An X ray photograph is



FIG 50. Trumble's arthrodesis. X ray appearances 1 month and 5 years after operatio

taken and if necessary the chisel can then be hammered in still farther ... is then rotated through 180 by means of a spanner fitted to the square en... then partly withdrawn and the graft is inserted in its place using the chis... as a guide The lower fragment of the femur is then adducted and brought in... as much apposition with the ischium as possible Any protruding portion ... the graft is removed A plaster of Paris spica is applied and maintained f... four months. It is then renewed as a short spica until X rays show that bon... union is complete.

Since this original description, Brittain has modified his technique usi... two chisels, a male and a female which are hammered on together into th... ischium. They can then be forcibly separated, and the grafts fitted betwe... the two as the chisels are withdrawn.

During the past three years the Brittain operation has been modified ... Foley (1949)[1] To avoid possible damage to the sciatic nerve a posterior a... proach is used. The sciatic nerve is defined and drawn out of harm's way t... ischium is exposed and the femur divided as shown in Fig 49 The chisel ... driven on into the ischium under direct vision and a broad tibial gra... inserted, the femur being displaced as in the Brittain procedure This opera... tion has the double advantage of ensuring the safety of the sciatic nerve a...

[1] *Journal of Bone and Joint Surgery* May 1949.

of enabling the surgeon to see his graft entering healthy ischial bone It has the disadvantage of being a rather bigger procedure and of necessitating the application of a spica with the patient prone Neither of these disadvantages is of much account with modern technique and apparatus

The results have been excellent In seventeen patients with an average age of nineteen years radiographic and clinical evidence of union has been present ten weeks after operation.

Two stage operation

In adults with active tuberculosis of the hip the operation of excision and intra-articular arthrodesis alone is inadequate because bony ankylosis is delayed and remains unsound for a very long time Nor is extra-articular arthrodesis alone always enough because in the older and less resistant patients the disease must be excised as radically in the hip as it is in the knee Any of these operations may prove more severe than has been anticipated and the patients who need them are often ill fitted to stand shock. Every possible means should be taken to minimize shock before, during and after operation e.g the application of a new plaster at the end of the operation should be avoided if possible It is unsafe to proceed to a grafting operation after a thorough excision The anaesthetist may say that the patient is still in excellent condition without diminution of blood pressure but these patients *are liable to lose blood pressure dangerously quickly towards the end of a* longish operation It is a wise rule to do the intra- and extra articular arthrodesis in two stages.

III For Exceptionally Extensive Disease

In some cases disease of either the acetabulum or the femur or both, is

1 so extensive that arthrodesis appears impracticable or
2 so active and widespread that life is threatened (most often in patients under 5 or over 50)

It is particularly in tuberculosis of the hip that the area of bone destroyed and replaced by a granuloma, organized but still permeated by living bacilli is sometimes so great that arthrodesis appears impracticable (see Fig 30) In such cases the authors have found it difficult to decide whether to carry on *with conservative treatment of the hip in order* that sufficient reconstitution of bone could take place to enable some form of arthrodesis to be carried out later on, or whether it would be best to do an immediate wide excision of the affected part A good many years ago the former course was taken, but experience made it clear that the very long-continued immobilization necessary was not well borne in adults and in children led to great atrophy and shortening of the limb More recently a wide excision of the diseased part has been adopted *involving complete excision either (a) of the acetabulum or (b) of the head, neck, and greater part of the trochanteric region of the femur*

The object has been threefold

(a) complete eradication of the extensive focus,

(b) avoidance of the atrophy of disuse,
(c) relatively early resumption of functio

(a) Acetabulectomy

Bankart[1] suggested total acetabulectomy in the treatment of tuberculosis of the hip At the time he advocated the procedure rather sweepingly His method was very radical and entailed removal of a complete section of the pelvic ring and the head of the femur was allowed to enter the pelvis

The authors have preferred to remove the diseased part of the acetabulum with such iliac bone as has been infiltrated but have always been able to retain posterior connexion between ilium and ischium behind the acetabulum The pelvic ring has not been broken and the upper end of the femur does not enter the pelvis

(b) Wide excision of the upper end of the femur Pseudarthrosis

When the head neck and trochanteric region are very widely diseased so that the normal bone tissue over this whole area is replaced by necrosed and sequestered bone and semi-caseous granuloma there is no reasonable hope of establishing arthrodesis by any means There can be no question but that the best interests of the patient will be served by the removal of the whole extent of rotten bone i e by a wide excision in which the aim is to bring about a freely movable flail type of joint The steps of the operation include

1 A complete exposure of the anterior and upper aspect of the joint
2 Division and excection of the capsule and synovial membrane
3 Division of all structures inserted into the great trochanter
4 Dislocation of the remains of the head and removal of all further muscular insertions into the digital fossa
5 A transverse osteotomy usually just above the small trochanter the site depending upon the extent of the disease
6 Excision and erasion of all diseased material in and round the acetabulum

At the end of the operation traction is applied and maintained uninterrupted throughout the next few months of treatment this is carried out in the authors practice either on an abduction hip-frame (see p 301) or on a Thomas knee-splint the former is preferable for the first six weeks as it gives the soft parts complete rest but after six or eight weeks the limb can be transferred to a Thomas splint which allows greater freedom In the authors experience end results are relatively good.

Time will prove whether ischio-femoral arthrodesis will replace pseudarthrosis to a considerable extent Low extra articular arthrodesis does not interfere with subsequent surgical access to the hip-joint But in the authors opinion some development of the operation is needed to ensure a synostosis

[1] Bankart *British Journal of Surgery* 20 April 1933 p 551 Presidential Address to British Orth. Assoc. London, July 27th, 1932

extremes of flexion and extension A pseudarthrosis on the other hand, needs no help from and throws no strain on the lumbar spine Figs 53 *a* *b* Fig 54 illustrate just such a case—for in this patient sound arthrodesis of a hip had to be exchanged for pseudarthrosis



Fig 54 Pseudarthrosis as a result of a deliberate operation. Case D.S

Case D.S

4.x.28	X-ray of Spine complete fusion and good calcification of diseased vertebrae
	" Hip almost complete destruction of head and neck
	Hip very unstable with limited movements.
7.ii.30.	Operation Arthrodesis of left hip
16.ii.31	Discharged.
20.xi.31	Started walking out of plaster Fig 53 *a* X ray shows bony union
18.iii.35.	Readmitted for reactivity of spinal lesion. Fig 53 *b* X ray shows extensive disease of L. 3 4 and 5 Psoas abscess present requiring repeated aspiration.
22.vi.36.	Operation Pseudarthrosis. Fig 54



Fig 55 a Pathological dislocation with adduction and flexion deformity, functional disability and much practical shortening



Fig 55 b After osteotomy Hip relatively stable, abducted.

When the hip is not fixed the authors do a *subtrochanteric osteotomy* allowing the upper fragment to adduct on the pelvis and putting the lower in a few degrees of abduction and flexion

The optimum angle of flexion varies with the occupation and sex of the patient Those who sit at their work and on their way to and from it welcome at least 30° of flexion and are all the better for 40° or 45°. On the other hand a man who stands at his work, e g stationmaster or general labourer will be much better with 25° or 30° Abduction of more than 10° is a disadvantage and where there is shortening it may be thought advantageous to abduct the hip sufficiently to lessen the shortening by an inch Internal rotation is a great disadvantage in a fixed hip Altogether one would say the best position for an ankylosed hip was that of external rotation of 10° to 20°, neither abduction nor adduction (except in some cases of considerable shortening when 10° to 20° of abduction may be best) and flexion of about 30° varying with occupation Osteotomy then, will often be advisable in order to correct marked divergence from this position. But one of the strongest indications for osteotomy is that of pathological dislocation with adduction (Figs 55a and b

In Table 3 is an assessment of deformity with the indications for operative correction.

TABLE 3

Good	*Doubtful*	*Bad*
Mobile:	Flexion range < 30°	Healing still unsound
Soundly healed.	A.G.E. > 140° < 160°	A.G.E. < 140°
Flexion range > 30°	Adduction deformity < 10°	Adduction deformity > 10°
A.G.E > 160°	Limits of doubtful strength.	Limits weak.
No adduction deformity	Articular movement with deformity of articular surfaces.	Instability
With strong sound limits.		
Smooth articular movement.	Pathological pseudarthrosis.	Pathological pseudarthrosis unsound or sound but with adduction deformity
Little or no deformity		
Without pathological dislocation.		
Fixed		
Ankylosis (fibrous or bony) sound and complete.	Ankylosis incomplet	Ankylosis unsound.
Flexion < 50°	Flexion > 50° < 60°	Flexion > 60°
Adduction < 5	Adduction < 10°	Adduction > 10°
Abduction < 15	Abduction > 15 < 25	Abduction > 25°
Rotation external < 20°	Rotation external > 20° < 40°	Rotation external > 40°
	Rotation internal < 10°	Rotation internal > 10°

$>$ = greater than. $<$ = less than. A.G.E = Angle of greatest extension.

[1] In ankylosis the degree of flexion deformity desirable depends on age and profession.

Drainage for severe persistent pyogenic infection of the hip

The risks of secondary infection in general and the means by which it can be avoided have been discussed (see p 47) Sepsis round the hip is a very serious complication which is likely to require radical drainage as a life-

saving necessity for sepsis must be stopped or the patient will inevitably drag out his life to a most weary and wretched end A few years ago one of the authors saw a lad of 20 who had suffered from tuberculous disease of the hip at the age of 3 Early on the joint had become secondarily infected and he had been in his previous hospital without adequate drainage for nine years When seen he had reached an advanced stage of lardaceous disease His ill ness was no longer due to the tuberculosis but to ill-drained pyogenic infec tion Cases such as this demonstrate the need for effective drainage by saucerization

The depth of the joint and its anatomical relations make the ordinary methods of drainage ineffective At the same time a reliable method of drainage can take advantage of the fact that persistent severe sepsis of a tuberculous joint inevitably leads to destruction and involves or requires fixation of the joint therefore the integrity of its intrinsic muscles and their nerve-supply is no longer a consideration And when the drainage neces sitates wide excision with pseudarthrosis the function of abductors and adductors is of secondary value, and should be disregarded if their sacrifice or partial sacrifice will give a better chance of sound healing It is only too common for a seriously infected hip to be drained again and again to the bitter disappointment and distress of the patient For this reason the authors have developed a more radical and decisive method of which the main feature is the wide exsection of muscular masses

Severe persistent sepsis in or round the hip has been one of the bugbears of surgery sinuses burrow among the tendons round the neck of the femur and the small trochanter or having penetrated the acetabulum produce abscesses and tracks within the pelvis The difficulty has been first of all to provide free drainage for these deep-seated lesions then—still more difficult —to maintain that freedom continuously over the period which is required for internal healing It is no longer now a matter of drainage of the hip-joint but of a much larger infected area which often represents a miniature rabbit warren of cavities and sinuses with sclerosed ischaemic walls

The presence of the sciatic nerve so hampers the posterior approach that drainage can only be free for a few days while it is futile to attempt to establish drainage of the hip by an anterior approach. The older methods do not give the surgeon a good view of the acetabulum but their gravest fault is that it is impossible to maintain free drainage for more than a very short time Furthermore the posterior approach produces a discharging wound in a most awkward position.

In 1921 as a result of profound dissatisfaction with these cases some originally tuberculous others the result of gun-shot wounds of the First World War one of us worked out a method which has proved effective and reliable ever since [1]

By the technique to be described something approaching saucerization of

[1] The Robert Jones Birthday Volume *Arthrodesis and other operations for Tuberculosis of the Hip* London, 1928, p 347 also *Tuberculosis of Bone and Joint* London, 1940

the joint is achieved and the advantage of the method lies not only in the full exposure it can give to the acetabulum after excision of the head but *in the access it affords for the adequate drainage of a still* deeper intrapelvic abscess via ilium or acetabular floor

It is often wise to obtain evidence as to the situation and extent of deep tracks and abscesses by lipiodol injection into the various sinuses and stereoscopic radiography Such an injection should be carried out on the X ray *table The lipiodol is injected slowly without much pressure* Sometimes the nozzle of the glass syringe is pressed lightly into the sinus, at other times a small rubber catheter is inserted as deeply as possible to carry the lipiodol

Technique The new method of drainage differs from the older ones in three ways the approach is lateral the incisions are at right angles to the *muscle and fascial planes and a large mass of muscular tissue is excised.* In most cases the approach is external only with a wide excection of the abductors and the great trochanter but an additional mesial approach is sometimes indicated with a similar wide excection of the adductors. The main nerves and arteries in front and the sciatic nerve behind are in no way *disturbed or endangered The considerable loss of abductors and adductors* is of no consequence if the hip is ultimately ankylosed and of little con sequence if pseudarthrosis is established since active weight bearing abduction is in any circumstances impracticable and adduction useless. Thus the great virtue of saucerization of this deep-seated joint is achieved by the *sacrifice of muscles which are no longer valuable (Fig 56)*

Group A

Position and splintage During the operation the patient lies undisturbed on a Robert Jones double hip frame or in a long plaster spica with a big *window (Fig 59) Alternatively if the hip infection is acute and the patient* only seen at a stage when operation is urgent he may come to the theatre unsplinted he is then put on a frame or in plaster at the conclusion of the operation while still anaesthetized In such a case the pelvis and the knee of the affected limb are raised from the operation table on sandbags to give free access to the outer aspect of the gluteal region Occasionally one has to deal with unfortunate patients with bedsores behind the pelvis or spine here neither frame nor plaster can for a time be used in this event after the complete operation the limb can be suspended in a Hodgen flexed 20 or 30 at the knee If a Hodgen is not available a flexed Thomas can be used Hodgen fashion but the ring must not be pushed up into its normal position or it will intrude upon the wound

Operation A long transverse incision is made from about 1 inch behind and below the anterior superior spine backwards with the centre about 1 inch above the great trochanter The skin edges are retracted up and down to expose a wide *ellipse of gluteal fascia covering the gluteus medius* and the anterior inch or two of the maximus Two deep transverse incisions are now

rapidly made by successive sweeps of the knife between each of which any bleeding vessels are clamped The upper incision directed inwards and slightly downwards divides the glutei down to the ilium just above the acetabulum the first sweep of the lower incision which is directed inwards and slightly upwards exposes the outer side of the base of the great trochanter which is at once divided by a wide chisel directed obliquely upwards to the digital fossa the trochanter is retracted up and the division of the

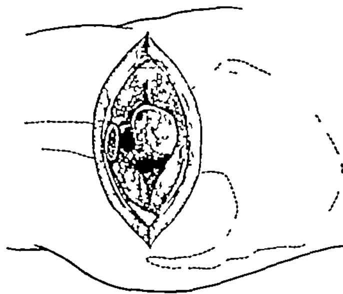


FIG 56 Showing transverse incision with wedge excision of all deep tissues.

soft tissues completed The knife does not approach the anterior crural (femoral) nerve in front or the sciatic behind. The whole mass of tissues consisting of glutei and great trochanter is now removed (Fig 50) and haemostasis carried out by diathermy by ligature or by interrupted haemostatic sutures of finest catgut in small curved round bodied needles The whole upper and outer aspect of the capsule of the hip lies exposed The capsule and synovia are removed and the underlying portions of neck, head, and acetabular rim are seen The neck is then divided near its base by a 1¼ inch chisel and the femoral head removed. The removal of the head is greatly facilitated (as it is also in performing pseudarthrosis for osteoarthritis) by the oblique removal of the upper acetabular rim by a 1¼ or 2 inch gouge of suitable curvature (this step is in either case beneficial) All the cartilage is gouged or scraped out of the acetabulum and the rotten bone curetted The discovery of an intrapelvic abscess indicates the removal of the acetabular floor with as much of the neighbouring ilium as will ensure free drainage It is the rule in this operation to leave no cartilage no diseased bone no dead tissue and no dead spaces. The erasion of the acetabulum should leave raw surfaces of vascular cancellous bone The operation can be done very

quickly if the chisels and gouges are large sharp and of fine material and thin section The exsection of the broad wedge of abductors and great trochanter provides really good drainage (Fig 57) the gluteal stumps retract for the incisions are analogous to the first cuts in a shoulder or leg of mutton

After the excision of the deep tissues, we used to draw the upper flap of skin

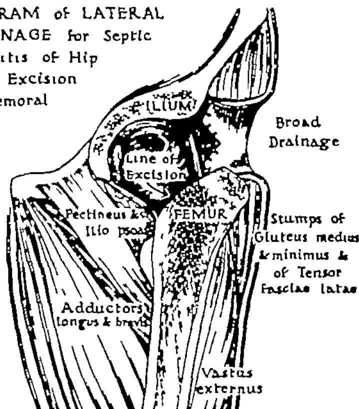


Fig 57 Lateral drainage. Method A.

fairly far down into the wound by a continuous catgut suture and often the lower flap too The sutured skin flaps thus cover the freshly cut muscular surfaces We found this point in technique very valuable in this and similar drainage operations as it reduced the pain of dressings and covered the more superficial raw areas from which granulations grew excessively When however there has been infection of the intermuscular planes the skin flaps should not be sutured deep to the deep fascia and nowadays the use of soft paraffin or paraffin wax and the infrequency of dressings have made this step less often worth while

Group B where ankylosis exists

The hip is ankylosed with two striking advantages—the obliteration of the joint cavity and the stabilization of the limb It is therefore most undesirable to dig out the head (Fig 60a) But there may well be sinus tracks

ramifying round the neck and the small trochanter In such cases after the lateral drainage down to but not through the neck it may be necessary to carry out a similar additional excection of muscular tissue on the inner side Portions of the pectineus and of the adductor longus and brevis are then exsected on the inner side as well as of all three glutei on the outer (Fig 60b) When this double drainage has been performed the skin in front remains intact over the tensor fasciae femoris sartorius, and rectus with the lateral cutaneous and anterior crural nerves and the superficial and deep femoral arteries veins and lymphatics and the skin behind covers the posterior part of the gluteus maximus together with the hamstrings the adductor magnus and the sciatic nerve As ankylosis exists splintage is unnecessary See Figs 60a and b

Haemorrhage The operation causes some loss of blood but only for a very short time and one of its great virtues is that the surgeon can see and catch the bleeding points any oozing from the vascular cancellous bone of the ilium ceases with a temporary gauze pressure followed by the much gentler pack. Some of these patients are exhausted by pain and toxaemia these have been transfused during the operation Of late years we have used the continuous drip method in almost all cases the rapidity of intake of blood can be matched to the loss during the operation and after the patient s return to his ward a much slower drip is kept up for 6 or 12 hours

Subsequent treatment

The success of this operation and the comfort of the patient depend on good splintage nursing and dressing The double hip frame is best but only if the nurses thoroughly understand the care of a patient on a frame a big plaster spica, with ample window and bridge (Fig 59) comes next and the suspension and traction of the limb on a Hodgen (or Thomas) is reserved for patients to whom neither of the former methods is applicable

After the removal of the head and most of the neck, upward displacement of the femur in relation to the innominate *must not* be permitted for such a movement would close the opening spoil the saucerization and bottle-neck the acetabulum The position is maintained by fixed extension on the frame by suspensory traction on the Hodgen or by a well fitting long plaster spica with the knee in flexion and a good hold on both ischial tuberosities.

Dressing The sides of the entrance should be lined with fine-mesh bandage impregnated with soft paraffin two or three 1 inch strips of corrugated rubber tissue and ample gauze drains reach to the bottom of the cavity (Fig 58) The main gauze pack should be enough to fill the funnel shaped wound, but each piece of gauze should run straight in from the surface and never be a long wick packed in by repeated pokes of a probe for this ancient packing technique leads to the formation of a big cavity which with its narrow neck resembles a chemist s flask.

Result. If the operation is well done the relief from illness and distress is dramatic If the subsequent treatment is good most of the cases will heal soundly in a few months The great gaping wound becomes a narrow scar

AMPUTATION AS A LIFE SAVING OPERATION

Indications

1 In some cases of persistent extensive disease with or without septic infection.

2 In elderly patients with a bad prognosis

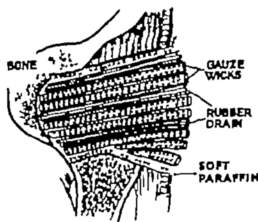


Fig. 58. Where the skin cannot be turned in as in Fig 57 because of scarring or sinuses the wound may be packed with alternate layers of gauze and corrugated rubber drains.



Fig 59 The operation is done either through a window in a spica or with the patient on a frame.

Flaps

The less muscular tissue the better masses of muscle are altogether out of place Only sufficient muscle should be left toward the bases of the flaps to make sure that they will be well supplied with blood Very often the flaps must be designed in relation to sinuses and cicatrices great care should be taken in the design of the flaps they must not be narrow pointed or thin, or they will slough

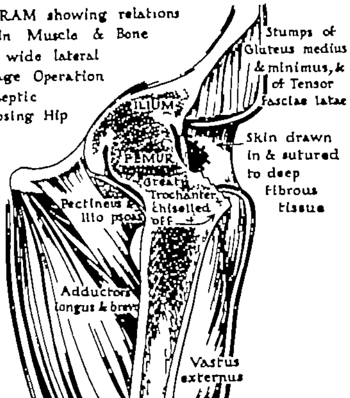


Fig 60 a. This illustrates the method of drainage when an external wound is sufficient.

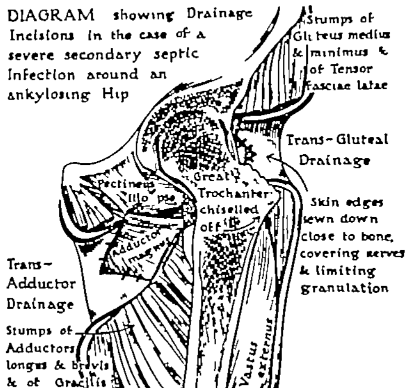


Fig 60 b When adductor drainage is also indicated

Method B

Incision

The authors begin the operation by tying the femoral artery and vein through a vertical incision just to the outer side of the femoral vessels, and dividing them between ligatures In a much-adducted hip it is wise to approach the femoral vessels from the outer side dividing first the upper part of the sartorius transversely 1 or 2 inches below its origin the anterior crural nerve is then divided and the artery and vein finally reached from the outer side for the ordinary route is surprisingly hampered by severe adduction.

So far there has only been made a vertical incision to the outer side of the femoral vessels This incision if the sinuses allow is carried downwards and inwards transversely round the back of the thigh then upwards and forwards to bring it back to the middle of the outer side of the original vertical incision. This gives a fairly long postero-internal flap and a short external flap

Nerves

One of the authors (G R G) in all amputations puts two clamps 1 inch apart on the main nerves then very carefully 'blows up this isolated segment of the nerve with 20 per cent formalin. After leaving this for one minute he removes both clamps and divides the nerve through the distal compression. He has found this injection effective in relieving post-operative pain both immediate and late

The avoidance of infection

Everything possible is done to carry out all the main haemostasis, flap cutting and muscle division and then, so far as possible to protect the raw surfaces before contaminating the wound by opening tuberculous or septic tissues This aim should be in the surgeon's mind even when widespread sepsis and multiple sinuses make its full achievement impossible.

When septic cavities in the ilium exist they are scraped out and left exposed as close to the surface as possible by bringing the skin edges close to the bone

Excision and erasion of diseased and necrotic tissues

It is first necessary to get rid of the limb with all that is left of the femur Whether this means disarticulation of a diseased joint or division of extensively sclerosed and partly calcified granulation tissue it may require rather rapid and apparently ruthless use of a big cutting tool and a broad 2-inch gouge will often be the handiest The moment the limb is away all bleeding vessels are clamped. The wound is then quickly douched with warm (not hot) saline and covered with warm saline towels while diseased necrotic and ischaemic tissues are erased and excised. Sometimes drainage of an intrapelvic abscess must be included.

Drainage

The original flaps will have been designed to facilitate suitable and adequate drainage. This should always be as short and direct as possible. Whenever there has been much sepsis the drainage should be broad, multiple, direct, and favoured by gravity.

Closure

The wound is rapidly closed by a number of stout, deep, interrupted stitches and accurate approximation of the epidermal edges by fine continuous sutures. This is followed by firm bandaging over a large number of big thick sheets of cotton wool.

Two stage amputation. Preliminary Pseudarthrosis

The authors have found in the frail and seriously ill patient a very great advantage in carrying out the amputation in two stages. In the first stage, using an incision which will conform to the outer limb of a truncated racquet, the hip is exposed and a typical wide excision and a pseudarthrosis is carried out and the wound closed or packed according to circumstances. Two or three weeks later the amputation is completed. Occasionally it may be wise to wait in the hope that the pseudarthrosis alone may suffice and amputation be avoided.

TABLE 4

Hip—Non-operative Treatment

Results

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Totals*
Well and working	29	29	9	2	1	5	— 75 — 58 per cent.
Untraced	3	9	2	2	1	1	— 18 — 14 ,,
Incomplete	11	3	0	0	0	0	— 14 — 11 ,,
Unsatisfactory	1	1	2	1	1	0	— 6 — 4 ,,
Died	10	2	2	1	0	2	— 17 — 13 ,,
	54	44	15	6	3	8	— 130 — 100 per cent.

TABLE 5

Hip—Operative Treatment

Results

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Totals*
Well and working	30	32	13	7	3	2	— 87 — 66 per cent.
Untraced	5	7	4	1	0	0	— 17 — 13
Incomplete	8	2	1	0	0	0	— 13* — 9
Unsatisfactory	2	0	1	2	0	0	— 5 — 4
Died	1	6	1	0	2	1	— 11 — 8 ,,
	46	47	20	10	5	3	— 133 — 100 per cent.

* 2 cases ages not known.

CHAPTER VII

THE SPINE

POTT S DISEASE

TUBERCULOSIS of the many parts of the spine forms the largest group of bone and joint cases The nature of the disease is of course fundamentally the same and the principles of its treatment are identical but the complexity of the anatomy and the presence and vulnerability of the spinal cord involve many problems which call for particular consideration

Pathology

1 *Age incidence* Spinal caries may occur at any age In Table 6 the per centage of cases occurring in each decade is shown and it should be noted that the largest figure is that for the age incidence of 20 to 30

2 *Site of the lesion* (Table 7a) The relative frequency with which the various regions of the spine are attacked is shown

3 *Nature of the lesion* The tiny original foci may be anywhere in the vertebral body but in children are most often close to the upper or lower epiphyseal plate In typical caries the lesion is seldom confined to one body and this is a point of great practical importance Hibbs[1] emphasized this and drew attention to the occurrence of small osseous foci in the bodies of several vertebrae above and below the more obviously involved and extensively destroyed centra. These foci are the result of a shower of tuberculous emboli distributed over a number of vertebral arteries at a time when the tissues are sufficiently susceptible to allow the bacilli to develop *It is impossible at any early stage to discover whether one two or a considerable number of vertebrae are involved*

Caries of the vertebral *bodies* with destruction or extrusion of the inter vertebral discs is much the most common form of the disease Occasionally there is a *sub-periosteal* infection in front of the bodies *under the anterior common ligament with little or no erosion. More rarely* a tuberculous focus develops between one of the bodies and the *posterior common ligament* and here it generally remains localized being liable to cause paraplegia without X ray evidence of bone disease

A focus appearing in the *lateral articulations laminae,* or *spinous processes* is also very uncommon disease confined to the lateral articulations occurs almost exclusively in the upper cervical region

From the epiphyseal region the disease spreads into the disc and adjacent bone in adults destruction of the former may be the only lesion seen in the radiographs of an early case

As the disease advances the eroded and decalcified bone gives way both

[1] Hibbs, R A. *Journal of Bone and Joint Surgery* 10 no 4, pp 805–14, Oct. 1928

under the pressure of body weight aggravated in the dorsal region by the ceaseless grinding respiratory motion In this way the characteristic deformity of Pott's disease the angular kyphos is formed Such pressure erosion if unchecked may continue until the spine is supported by the thoracic cage

Osteogenesis does not occur except at a distance in time or in space from an active tuberculous lesion

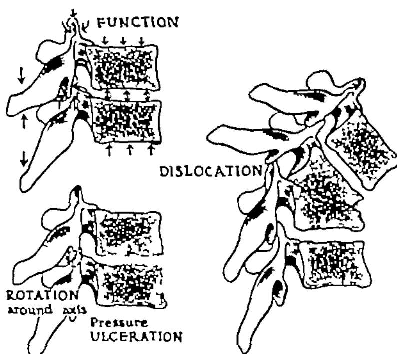


Fig 61 Diagram of dorsal vertebrae in sagittal section to show effect of pressure on decalcified bone.

This absence of any constructive bone reaction is peculiarly harmful in tuberculosis of the spine for several reasons Not only is the spine the foundation of posture movement and respiration and the protector of the spinal cord, but it is so constructed that a defect in the somatic column leads first to a subluxation and in time to a dislocation of the lateral articulations. Advanced spinal caries has been truly and vividly described as a pathological fracture-dislocation of the spine Fig 61 demonstrates the process This makes it imperative first that the erosion be checked as quickly as possible and the rotten bone protected from compression secondly that special care must be taken later on to restore the lost stability Many considerations are involved. It was with the object of minimising the loss of stability that Menard advocated what he termed orthopaedic correction. But it must be remembered that in his time there was no operative posterior spinal fusion for neither Albee nor Hibbs had made their contributions which have been of

such immense service in this field. Menard taught that it was necessary for the stability of the spine that its angulation should correspond to the amount of bone destruction that healthy bone above the area of erosion should lie in close apposition to healthy bone below In the lumbar region a certain amount of destruction can be accommodated by telescoping here ortho paedic correction can often be achieved without angular deformity Here



Fig 62 a



Fig 62 b

These figures illustrate Waldenström s technique.

too intersomatic fusion occurs more readily than elsewhere Menard s advice has been accepted by many orthopaedic surgeons, but Waldenström of Sweden has shown that it is possible to avoid an appreciable angular deformity in the presence of considerable destruction by carefully adjusted padding of his plaster beds and later to consolidate the position by means of a strong straight tibial graft See Figs 62a and b In the authors opinion modern methods of splintage followed by grafting can protect infected bone during the phase of recalcification and favour the restoration of sound well trabeculated bone in this area The rotten bone would have been regarded by Menard as worthless and expendable Indeed he would have promoted its disappearance under increasing angular deformity in order to allow un infected bone above to meet uninfected bone below It seems right to aim at the maintenance of a position much nearer the anatomical ideal of Walden ström

Cold abscess

This is primarily a collection of debris and as the destructive process is usually greatest in front the abscess starts in front and on both sides of the affected bodies. And here in the *dorsal region* it often remains thus if



Fig 63. Tuberculous lesion of D 4, 5, 6, and 7 with a tense spherical paravertebral abscess of the type which often causes pressure on the cord.

destruction is allowed to go on the abscess may become exceedingly tense and as a result of the internal fluid pressure and the erosion of the whole antero-posterior diameter of the bodies some of the contents may work their way backwards between the diseased bodies into the extra dural space of the spinal canal This, as we shall see is one of the commonest causes of paraplegia. Much more often, however the abscess will insidiously travel down one or both sides of the bodies to form the typical distant abscess e.g psoas abscess from caries of the lumbar vertebrae

The appearance of an abscess is ordinarily associated with activity of the



Fig. 64 a.



Fig. 64 b.

Psoas abscess.

destructive process yet occasionally an abscess will come to the surface long after the arrest of the disease

On the other hand hints as to the activity of the disease can be obtained from the appearance of the abscess In the dorsal region Fig 63 for instance one learns to associate a typical spherical or fusiform shape with an active lesion and a crenated edge with a quiescent lesion In the course of time the contents of a spinal psoas abscess will often calcify and the appearance of calcification in a radiograph is reassuring

The contents of an abscess are usually purulent but they vary in their consistency in general an abscess containing thick flocculent material is indicative of a quiescent lesion A more reliable guide to the state of the lesion is the relative number of tubercle bacilli in a stained film

The abscess may appear in various sites either adjacent to or distant from the bony lesion

In the upper cervical region a paravertebral abscess is retropharyngeal and presents a large softish swelling at the back of the throat Lower down the paravertebral abscess is led by the fascial planes of the neck laterally towards the surface

In the dorsal region as has been mentioned above the abscess may remain localized and, if so is a common cause of paraplegia. On the other hand these abscesses may track along the course of either the anterior or posterior primary division of the spinal nerve or again they may infect by infiltration and rupture into (a) The pleura Seddon, 1936 Starkie 1938 Emrolaev 1939 Brooks, 1942 (b) The bronchi Imbuch, 1937 De Lucchi, 1940 (c) Œsophagus Seddon, 1936 (d) Œsophageal diverticulum Brand 1939 (e) The aorta Somerville and Wishart

In the dorso-lumbar and lumbar regions the abscess commonly tracks down the psoas sheath to appear below Poupart s ligament or more rarely passes out of the pelvis into the buttock and appears on the outer aspect of the thigh Very seldom it may follow a spinal nerve and appear posteriorly

A cold abscess may be mistaken for a lipoma and psoas abscesses sometimes have an unfortunate if superficial resemblance to a hernia (Fig 66)

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DIAGNOSIS

History

The first symptom is usually pain in the back felt continuously or



Fig. 65 a.

1



Fig. 65 b.

Psoas abscess.

repeatedly at the same level generally a tired ache brought on or aggravated like tiredness by prolonged walking standing or sitting up or by vibration The pain has no regular characteristics it is aggravated by movements of the spine and particularly by jarring The local pain in the back becomes



FIG. 66. Psoas abscess injected with lipiodol The abscess arises from tuberculous disease of L. 4 and 5.

complicated at a later stage by referred pain due to the pressure on or irritation of a spinal nerve This often is described as a sense of constriction round the chest caries in the lower dorsal spine often causes abdominal pain and has led to many a laparotomy from a wrong diagnosis this not only involves the postponement of the right diagnosis and treatment but may well lead to serious crushing of the diseased area of the spine while the protective muscular spasm is relaxed by the anaesthetic

Sometimes, particularly in adults the first really noticeable sign is dragging and incoordination of the legs Not uncommonly however the patient s

attention is first attracted by a curious soft swelling in the groin or lumbar region not to be mistaken for a lipoma or a hernia!

In regard to general health there may have been a noticeable falling off in stamina and activity Children may be described as fretful and easily tired, and restless at night

A watchful mother will often have noticed this so-called pretubercular phase and then the beginning of a little restlessness at night Next she will see that the child walks with rather a stiff carriage and is careful about stooping Thus the orthopaedic surgeon is often fortunate enough to see a young child before any deformity has occurred.

Examination

The patient may have developed an attitude which is characteristic of the disease in various parts of the spine e.g the patient with a lesion in the cervical region is inclined to support his chin on his hands. The muscle spasm which extends beyond the diseased area sometimes produces the well known erect posture and aldermanic gait The patient walks with short deliberate steps to avoid any jarring of the spine With lumbar disease he may when sitting, take part of the weight of his body on his hands

But so far as adults are concerned, every doctor must see hundreds of cases of fibrositis or osteoarthritis before he comes across one case of spinal caries It is small wonder then that this history when given by an adult should not always arrest sufficient attention to make the doctor insist upon full examination and radiography

On examination local rigidity from reflex spasm especially of the erector spinae *is characteristic If the case is far advanced there will be a tell tale* deformity a knuckle or an angular kyphos

On palpation there may be localized deep tenderness over the spines of the affected vertebrae and on jarring the spine pain will be referred to the same area. But nowadays, with the advantage of radiographic diagnosis one need seldom have recourse to these signs which involve just a little unnecessary traumatization

The nervous system must also be examined both on general grounds and because there may be early signs of pressure on the cord or the cauda equina.

Finally abscesses should be sought and in lesions of the dorso lumbar spine a fullness can often be felt in the iliac fossa with or without fluctuation

Radiography

In children clinical examination may go far toward a diagnosis, often indeed, the diagnosis is obvious at a glance but in older patients at an early stage the diagnosis can only be arrived at with the help of X rays here again however though radiographs are much more likely to help than in the big joints, one must be prepared to make a provisional diagnosis in the absence



Fig 67 M.M age 3 3 months' history



Fig 68. K.N age 6, 3 years history

of radiographic signs of erosion. In adults the earliest radiographic sign is often a loss of intervertebral disk space (pincement) with perhaps some erosion of the adjacent somatic articular surfaces and before long decalcification of these bodies In children destructive changes are visible at an early stage Later varying degrees of destruction and collapse are seen In antero-posterior views lateral angulation and abscess shadows should be looked for

Differential Diagnosis

For the purposes of discussing differential diagnosis it is useful to consider children and adults separately

Children

In almost every case but perhaps most in children the doctor s difficulty arises from the insidious undramatic onset A mother may rather casually bring her child saying that he or she gets unduly tired in the evening and liable to aches and discomforts and the doctor may so easily and almost as casually reciprocate with a tonic or change of air! With early Pott s disease a child is out of sorts and run down Other conditions which may be mistaken for Pott s disease are the following

1 **Osteochondrosis of the spine.** *Age incidence 6–12 years. This is an* extremely rare condition (illustrated in Fig 70) often called Calvé s disease [1] belonging to the group of epiphyseal disorders misnamed osteochondritis, associated with a vascular accident and strictly analogous to Perthes disease Köhler s disease &c See pp *61* and *144*

The condition is apparently due to a temporary arterial ischaemia of the affected centrum due to embolism or thrombosis of the artery or arteries supplying the affected part it exhibits the resultant aseptic necrosis characteristic of this form of osteochondritis

2 **Developmental abnormality** Age incidence 10–16 years Fig 71 illustrates another form of osteochondritis *in which the plate of the anterior corner of the affected vertebral body is separated* off either for a time or permanently The radiographic picture might be mistaken for that of some infective process Actually the condition has no pathological significance nor any symptoms

3 **Scheuermann s disease.** Age incidence 6–14 years This is an epiphysitis affecting a number of vertebrae and producing fragmentation and increased density of the epiphyseal plates and some wedging of the vertebral bodies. It gives rise to a rounded kyphosis not an angular kyphos and the relative freedom from pain with an absence of general symptoms complete the distinction (Fig 72)

[1] Calvé *Journal of Bone and Joint Surgery* 7 41 1925.



Fig 69 a.



Fig 69 b.

Figs 69 a and b. Showing the different regions of a vertebral body in which the disease may start (a) shows a central lesion, (b) shows two lesions. The lower has caused destruction of the disc and adjacent surface of the vertebral bodies and the upper one is a periosteal lesion of the anterior surface of the body



Fig 70. G.S. Osteochondrosis.



Fig 71 M.R. Two forms of the disturbance of the osteochondral relations. The upper represents the so-called Schmorl' disease.

4 **Schmorl's disease** Age incidence 12–24 years Schmorl s disease is a derangement of the relations between the intervertebral discs and the vertebral bodies associated with a defect in the upper or lower growth plates of the bodies and partial herniation of the discs upwards or downwards The resulting disturbance of the anatomical relations appears to interfere with



Fig 7_ Adolescent kyphosis. Some degree of osteochondrosis.

the normal stability of the part, and patients are liable to persistent localized backache very suggestive of spinal caries but the length of history, the absence of any angular deformity and the radiographic picture will distinguish this from caries The X ray appearance (see Fig 71) will be recognized once its characteristics have been fully grasped. It is of course important that neither Scheuermann s nor Schmorl s disease should be mistaken for tuberculosis lest the parents be unduly alarmed and the patient put through a long course of unnecessary immobilization Treatment varies with the severity of the symptoms and the radiographic changes Often nothing more is required than a certain amount of daily rest in decubitus erector spinae exercises and some restriction of activity, but in severe cases six months or

more on a plaster bed, giving rest and a gradual correction of the rounded kyphosis, is necessary and must be followed first by plaster jackets in full extension and later by a light support and postural exercises.

5 **The kyphosis of 'rickets'** Age incidence 1–10 years A number of



Fig 73 Adolescent kyphosis associated with strongly positive Lambrinudi sign. The anterior superior spine and the level of great trochanter are marked.

young children show a prominent rounded kyphosis in the dorso-lumbar region without much in the way of the general manifestations of rickets, this deformity is rounded rather than angular mobile rather than rigid and quite painless Lateral X rays show the deformity without any sign of inflammation erosion or disorganization of bodies or discs.

6 **Adolescent kyphosis.** Age incidence 12–18 years This is a similar condition arising in children either from poor posture or as a result of a congenital tightness of the hamstrings Lambrinudi pointed out the associa

tion of these conditions.[1] This congenital tightness is shown by the anterior superior spine remaining above the level of the great trochanter when the patient stands and tries his utmost to touch his toes without flexing his knees (*Fig* 73) This movement should not be forced



FIG 74 S.A.C. child aged 14 months. Acute angulation; unknown origin possibly developmental. Similar conditions are sometimes found associated with glandular imbalance e.g. cretinism.

7 **Fusion of unknown origin probably developmental.** A child or adult may be seen on account of the deformity due to an angular kyphos but without other signs or symptoms Radiographs may show the fusion partial or complete (Figs. 75 and 76) of two vertebrae While the fusion may

[1] Lambrinudi, *Brit Med Jour.*, 3 Nov 1934, 2, 800.

be developmental in origin the possibility of tuberculosis or some other l
grade infection cannot be excluded At the stage shown they have no patl
logical significance except that in later life there may be a liability to d
comfort from mechanical strain above or below the deformity

8 Scoliosis At first sight it would appear impossible to mistake scolio



FIG 75 Fusion of vertebrae. Origin unknown. Possibly due to old tuberculosis without obvious illness.

for Pott s disease, and this is so in the vast majority of cases. But the authors have on one or two occasions found it extremely difficult to distinguish an upper dorsal scoliosis beginning in the first year of life from Pott s disease Radiographs at this age in the upper dorsal region are rather inconclusive and one must in such an event treat the patient on a spinal frame for a time on a provisional diagnosis. At the other end of the scale are those cases of great deformity such as are illustrated in Figs 77 and 78 The scoliosis has almost disappeared in the extreme degree of kypho-lordosis This deformity may be mistaken for Pott s disease and this is still more likely in regard to those very rare cases of paraplegia resulting from scoliosis In such cases the paraplegia is not the effect of pressure from disease but due to the extreme distortion

of the spine Laminectomy alone is of course, utterly futile if something radical has to be done it will involve extensive operation, including probably section of intervertebral nerves on the convex side and radical division of



Fig 76. Fusion of vertebræ Two pairs of bodies involved. The cause of such lesions is often uncertain. It may be infective or congenital.

pedicles on the concave side, in order to allow the cord to adopt a straighter, freer course But the treatment of scoliotic paraplegia is in truth very unsatisfactory The condition of the cord is analogous to that in some cases of late Pott's paraplegia associated with extreme deformity and is probably due to cord atrophy from prolonged strain and tension, rather than to any cause which can be relieved by operation.



Fig 77 X ray of idiopathic scoliosis showing lateral curvature and rotation of vertebrae No evidence of infection.



Fig 78. Idiopathic scoliosis showing a large hump. Compare with tuberculous kyphos Fig. 70.

The distinctive feature of scoliosis as against tuberculosis is the absence of erosion pincement decalcification and abscess

9 **Rheumatoid spondylitis** In adolescents or adults This leads to a rounded kyphosis involving many vertebrae akin to polyarticular



Fig 79 Well compensated tuberculous kyphos. Note that the deformity is that of the spine whereas in scoliosis the prominence is the ribs secondary to extreme rotation of the vertebrae with lateral angulation.

rheumatoid arthritis Lateral radiographs show more or less equal narrowing and wedging of a number of discs and in the end some wedging of the bodies with general decalcification but without erosion. It occurs in an extreme form in elderly people female far more often than male, and in these the decalcification may be so extreme that vertebral bodies collapse (pathological crush fracture) with formation of an angular kyphos Typical root pains



FIG 80 a.



FIG 80 b

Spondylitis ankylosa.

follow and one is at once confronted with the more likely diagnoses of tuberculosis or secondary carcinoma The radiographic evidence of rheumatoid spondylitis throughout the dorsal and lumbar spine together with a congruous clinical picture and a history of a stiff uncomfortable spine too long for either tuberculosis or carcinoma are strong diagnostic points The absence of any discoverable primary growth and of any history of an operation for such a growth is confirmatory but by no means conclusive for secondaries



FIG. 81 Appearance of sacro-iliac joints in early spondylitis ankylosa.

to intestinal carcinomata in old people not uncommonly become manifest before their primary growth

10 **Spondylitis Rhizomelique, or Ankylosa.** Age incidence 18–30 years. This is a curious ankylosing spondylitis which affects the whole spine except a few of the upper cervical vertebrae and if it runs its full course welds it into one solid and completely rigid mass of bone which includes the costo-vertebral joints (Figs 80 *a* and *b*) Although the fully developed disease is easily distinguished from tuberculosis of the spine, it may begin with local pain and rigidity and be difficult to distinguish except by the characteristic development of ankylosis *It is however possible to identify this disease* at an early stage by radiographs of the sacro-iliac joints (Fig 81) This condition then is characterized by an early affection of the sacro iliac joints ending in fusion and by a painful spondylitis The hips are commonly involved with perhaps insidious but solid bony ankylosis The part of the spine affected is painful until it becomes ankylosed and the process travels slowly from one part of the spine to another



Fig. 82 a.

Fig. 82 b.

Figs. 82 a and b. Extreme osteoarthritis. ? also Charcot element (W. R. +)

11 Osteoarthritis Age incidence over 40 years In the elderly, pain in the spine is commonly caused by osteoarthritis and this pain may be referred in the form of sciatica Radiographs with their evidence of osteogenetic re action rather than of erosion will distinguish this condition from tuberculosis (Fig 82) And it is important that this investigation should be undertaken lest caries should remain unrecognized in a patient whose pain and stiffness is loosely diagnosed as osteoarthritis

12 Pyogenic disease of the spine (Figs 83 *a* and *b*) This is rare It may be primary or part of a pyaemic infection The infection differs from tuberculosis in that the spinous processes, pedicles, and laminae are involved about as often as the bodies Perhaps the commonest situations are the lower lumbar vertebrae and the sacro-iliac joints, but so far as the posterior parts of the central column are concerned, there appears to be no favourite site

There are two clinical forms the acute and the chronic In the former the symptoms are very acute and an abscess quickly collects in the lumbar and the sacro-iliac regions the abscess is often very deep and requires a good deal of penetration preferably by Hilton s method, in order to drain it The differential diagnosis of this type from tuberculosis is largely a matter of history sudden onset high fever and acute pain No radiographic abnor mality is as a rule detectable within the first few days

The chronic form except in its distribution is much more like tuberculosis a slow developing abscess in connexion with the laminae may cause para plegia—and this differs in its march from the typical Pott s paraplegia in that the sensory columns are likely to be affected first The diagnosis may be sug gested by a high leukocyte count and confirmed by the type of pus and micro scopical examination of a smear and the culture afterwards. An immediate microscopical diagnosis is valuable in order that drainage may be instituted.

13 Neoplasms. (*a*) *Secondary carcinoma* Age incidence over 40 years This is very rare except after middle age but it is sometimes most difficult to distinguish from caries particularly when one body has collapsed The absence of any obvious primary growth must be discounted, though a posi tive history of a previous mammary or other carcinoma is more than sug gestive (Fig 84) In metastatic carcinoma there is relatively less knuckle or angulation and relatively more pain. There is an even and often extreme, decalcification, and total collapse rather than progressive erosion but occasionally radiographs will show bone flakes in the paravertebral tissues which in appearance and position simulate the bone debris of caries. The metastasis of a prostatic carcinoma may show increased density of bone

(*b*) *Sarcoma* (Figs 88 *a* and *b*) This usually involves one body it is very rare But an osteolytic sarcoma of the lateral mass of the sacrum is not very uncommon.

Case D B–H Figs. 88 *a* *b* and *c*

First seen 6.xii.35 with a history of increasing pain and stiffness of the neck with a very large swelling behind the back of her throat. There was a definite history



Fig. 83 a.



Fig. 83 b.

Figs. 83 a and b. Pyogenic infection of the spine distinguished from tuberculosis by sclerosis and new bone formation.

that there had been leakage from this soft swelling into the throat There was embarrassment of respiration and difficulty in swallowing

The radiograph showed extensive destructive disease of C 3 4 and 5 with what appeared to be an enormous pre vertebral abscess. The swelling felt soft, but on inspection through the mouth there was no appearance of leakage

The patient was put on a frame with head piece and the swelling was approached laterally with a view to exploration and lateral evacuation if it proved to be an



FIG 84 Woman over 60 Secondary carcinoma. Note destruction of the body while the discs are not involved.

abscess, as seemed probable though not fully certain. With diathermy for control of haemorrhage in case of need, we exposed the mass, inserted a needle with negative result, cut out a portion which proved to be solid dark red material suggestive of giant cell tumour It seemed worth while endeavouring to remove the tumour We did this by means of blunt dissection and gouge excavation of the vertebral bodies, using diathermy haemostasis.

We put her in a plaster collar 26.I.36, and sent her to Dr Webster of the Middlesex Hospital, for radiotherapy She did very well quickly lost her pain and all embarrassment of breathing and swallowing

On 8.iii.37 we strengthened the area of destruction by posterior spinal grafting (See Fig. 88 b)

She was last seen 24.x.49 see Fig 88 c.

(c) *Multiple myeloma* Age incidence 30–60 Radiographs show decalcifica

tion advancing to total replacement localized to one vertebral body, or more often several Radiographs of other bones may show similar pictures The diagnosis is confirmed by the discovery of Bence-Jones proteose in the urine.

(d) *Haemangioma* Symptoms indefinite pain occasionally paraplegia.



Fig 85. Solitary plasma cell cytoma showing extensive destruction with a small spherical soft tissue shadow which in this instance is not an abscess but expanding tumour

Radiographs show a characteristic mottling of the body, and in antero-posterior view the replacement of lateral concavities by convexities the body has lost its waist.

14 Spondylolisthesis. (Figs 86 and 87) Age incidence 8–18 years This is a displacement of the fifth lumbar on the sacrum History either a parent has noticed deformity or the patient complains of stiffness and aching in the back and pain down the outer sides of the lower limbs

The condition is due to one of two causes most commonly to a defect in



FIG 86 a LP aged 23. Spondylolisthesis. Before treatment.



FIG 86 b Same case after treatment A graft carrying the weight from the 3rd and 4th lumbar vertebrae to the sacrum is shown.

the development of the vertebral ring between the body and lateral articulations on both sides this allows the body to slide forward, leaving the lateral articulations in their normal positions Occasionally however this subluxation is allowed to occur owing to a defect in the lateral articulations themselves

The back view of the patient is characteristic (Fig 87) and the radiographic appearance (Fig 86) decisive The deformity developes in adolescence

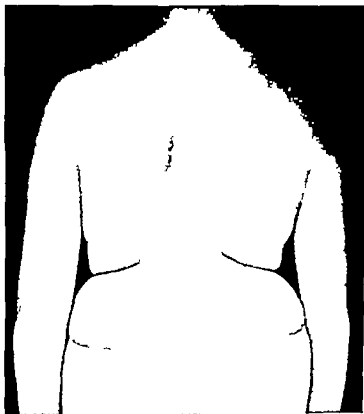


FIG 87 K P The characteristic appearance of spondylolisthesis.

15 Kummell s disease This condition is characterized by pain in the region of a wedged vertebral body and is a late manifestation of a crush fracture In some cases the original fracture may have been impacted with little immediate deformity Such a condition is easily missed at the time and will be so missed unless *lateral* radiographs are carefully examined This is serious because lack of protection is likely to lead to a severe secondary increase in deformity

Occasionally it may be very hard to differentiate Kummell s from Pott s disease Valuable pointers in favour of the former are an emphasis on accident in the history and the survival of the intervertebral discs Radiographs show a wedge shaped vertebra with *discs still present* though sometimes badly distorted and narrowed



Fig 88 a D.B.H. Destructive disease C 3 4 5 with large prevertebral shadow



Fig 88 b Same case after operations for eradication and fusion



FIG 88 c The condition twelve years later



FIG 89 A woman of about 45 with an angular kyphos due to a collapsed vertebra associated with osteitis deformans.

16 Lumbago An adult complaining of pain in the back coming on insidiously and proving persistent is not suffering from lumbago and if on examination there is loss of mobility of the spine the diagnosis of Pott s disease should be excluded by radiographs before the case is labelled as one of fibrositis or strain

17 Hernia of the intervertebral disc The central part of the nucleus pulposus of the intervertebral disc sometimes herniates backwards producing a rounded prominence in the anterior wall of the spinal canal This may give rise to an indefinite pain in the back with referred pain down one or other leg or both legs due to pressure irritation of the cauda equina It is indeed a specific cause of an obstinately intermittent sciatica

The extrusion of the nucleus pulposus causes a narrowing of the disc space which may be sufficiently marked to resemble the pincement of early caries The absence of X ray changes in the majority of cases and the relation to trauma will help to make the diagnosis Rest in bed relieves the pain but it returns later The condition can be provisionally diagnosed by lumbar puncture and the cerebrospinal fluid picture and confirmed by lipiodol injection with accurate radiographic investigation on a tilting X ray couch The filling defect is opposite the disc whereas in the spinal tumour type of posterior caries (subflaval) it is opposite a body

18 Aneurysm The pain of aneurysm may be mistaken for that of Pott s disease But it should as a rule be possible to distinguish any anterior pressure absorption due to aneurysm from the anterior erosion due to subperiosteal tuberculosis the former is shaped clear cut and not associated with irregular erosion and decalcification.

19 Paget s disease (Osteitis deformans) Age incidence 40 years upwards. Occasionally one or more vertebral bodies may collapse as a result of this disease producing a clinical picture as regards both angular deformity and pain exactly like that of tuberculosis Here the age period may be suggestive other bones may be affected and the radiographs of the spine particularly lateral, will demonstrate the typical coarse trabeculation of *Paget s disease.* (See Fig 80)

TREATMENT

It is well to begin by a consideration of some of the problems with which we are faced Spinal disease is the most serious form of skeletal tuberculosis and valuable information can be obtained from an analysis of the mortality rate

A recent investigation by one of us (E W S) of 664 patients showed that 241 had died an apparent mortality of 36 per cent Taken at its face value this figure probably points a rather unduly gloomy picture as not all the deaths were due directly to the spinal disease and in some the early treatment was totally inadequate The mortality figure for those who had received adequate

treatment from the start would be much lower probably in the region of 25 per cent, of which about half died as a direct result of spinal caries In this series 107 died as a result of spinal disease or its complications 97 died of tuberculosis in some other form and in 35 death was due to causes unrelated to either Table 6 shows the increase in mortality with age rising from 23 6 per cent. in children to 57 per cent in disease first diagnosed over the age of 60 years The table also shows that 11 out of the 26 children who died did so after a period of more than 10 years whereas in those who developed the disease over the age of 60 years 8 had died within 3 years and the remaining 6 were either alive or had been lost trace of after 10 years

The figures showed a very high mortality rate in the first two years after diagnosis rapidly falling in the subsequent follow up This fact is well illustrated in the table

TABLE 6

Tuberculosis of the Spine Death in Age-groups

Age	*Total of patients dead*	*Years after Diagnosis* 1	2	3	4	5	7	10	10+	*Total of patients seen*	*Percentage dead*
0–9	26	5	3	1			4		11	109	24
10–19	40	6	8	1	3	4	0	7	5	125	32
20–29	88	18	22	14	7	7	7	4	9	221	40
30–39	29	7	4	7	1	2	6	2		107	27
40–49	24	9	5	2	4	2	2			47	51
50–59	19	7	6	1	1	1	–	1		34	56
60	8	2	5	1						14	57
TOTALS	234	54	53	27	16	16	27	16	25	657	

TABLE 7 *a*

Level of Lesion in Relation to Certain Causes of Death

	Case	*Total deaths*	*Toxaemia T.B or sepsis*	*Amyloid*	*Meningitis*	*Miliary or Generalized T.B*
Cervical	21	0	3	2		
Dorsal	266	81	10	6	14	15
Dorso-lumbar, Lumbar, Lumbo-sacral	330	130	43	27	15	19
Double lesions	47	21	7	2	2	
	664	241	100		65	

TABLE 7 *b*

	Cases	*Deaths from toxaemia and amyloid* %	*Deaths from meningitis, miliary, generalized* T.B %
Dorsal	266	16 = 6	29 = 10 9
Lumbar group	330	70 — 1	34 = 10 3

Toxaemia and amyloid disease account for the majority of deaths while generalized tuberculosis and meningitis are the second most common cause. As would be expected toxaemia occurs most readily in lumbar disease as it is in this region that abscesses and subsequent sinus formation are found. The mortality from generalized tuberculosis is unaffected by the region of the spine involved. Table 7 b

On the whole the extent of the spinal lesion bears little relationship to the mortality with two exceptions. Firstly the mortality rate for multiple spinal lesions is higher than for single ones and secondly in children where gross deformity produced by extensive destruction of vertebral bodies often leads to death in early adult life from intercurrent infections or renal disease.

These facts indicate how treatment may help to deal most effectively with the disease. First as the risk to life is highest in the first two years early diagnosis and prompt efficient treatment is of paramount importance. Secondly every attempt must be made to prevent sinus formation and should one occur to prevent it becoming secondarily infected (see p. 40)

Thirdly the reduction of any spinal deformity to the minimum is of the utmost importance and this is so not only on account of the appearance but it is a vital matter in the truest sense. Health activity and expectation of life all depend upon good capacity and free movement of the thorax. It is unfortunately true that the review of the children as they leave hospital with relatively small and well compensated kyphos may be completely deceptive for a few years later their deformity may be extreme and obvious. Some of this late deformation may be due to the insidious persistence of the disease and the consequent increase in the destruction and angulation because they have been allowed up before sound healing has taken place and with inadequate protection but it is probable that the greater part is due to the cessation of growth in the vertebral bodies where the growth elements have been entirely destroyed by the disease and continuation of growth in the healthy posterior vertebral parts which have entirely escaped the disease. This secondary angulation is strictly comparable to that due to the deformed growth of a long bone which has had part of its growth disc destroyed by inflammation or injury. This of course emphasizes the importance of early discovery prompt and continuous immobilization and good general treatment in order to minimize the destructive processes in the vertebral bodies.

The period of conservative treatment in decubitus is necessarily long if evidence not only of arrest of erosion but of advanced recalcification is awaited before the patient is allowed up. Children can with advantage be kept lying down throughout this period, for they thrive while at rest in the open air. Most adults however cease to gain in health and activity after six months or so especially if strictly immobilized on any form of splint or plaster bed and a little later may begin to lose rather than gain. Posterior spinal fusion is indicated in adults earlier and much more often than in children. The building up of a strong (internal) posterior spinal support is of advantage earlier in order to enable the patient to get up more quickly and more often

because in adults sound reconstitution of the vertebral bodies seldom takes place At the same time it is essential to regard three things first that the operation should be postponed until the patient is in good general health second that for some months after the bacillaemic shower which initiated the disease radiographs may not indicate the total number of vertebrae which were infected by bacillary deposits third that the protection of the spinal lesion afforded by the operation does not lessen the need for general treatment

To disregard the second of these points may be particularly unfortunate early radiographs will have shown the broken-down areas in perhaps one or two centra but not infiltrated areas in several others above or below with the result that the extent of the fusion is insufficient and some outlying lesion may develop just above or below the protected area Sometimes such a lesion will be dormant and only become active and painful a year or more after the patient has left hospital and resumed some activity Nothing is more disheartening to the patient or disappointing to the surgeon

Operative fusion is an incident in general treatment, but it will be realized that its timing is of considerable importance The general treatment begins before the graft and will be carried on after for a period which cannot be laid down in a book but must be judged in regard to each case In adults particularly the chance of successful general treatment comes but once and unless this none-too-golden opportunity is grasped and made the most of the patient is likely to become the victim of other metastatic lesions due to the persistently active disease of the mediastinal or retroperitoneal lymph glands. The first few months of general treatment comprises almost complete rest of the body The patient is given all the advantages of an open-air hospital with periods of exposure to the sun and wind is fed well and kept content and interested by environment education, and occupational therapy

LOCAL

I In the active stage

At this stage the spine must as a whole be immobilized on some form of dorsal splintage in full extension or in some cases in hyperextension. If there is an angular deformity gradual correction, by development of compensatory curves is undertaken This means direct pressure by body weight on the whole of the kyphos The object of the manœuvre is indeed, to push the kyphos forward as a whole while preserving the apposition of the diseased vertebrae and to bring the commencement of the compensatory curves as close as possible above and below This is achieved by the use of carefully placed and progressively thickened kyphos pads so arranged as to assist in the formation of adequate compensatory curves just above and below the site of the lesion (Fig 00) Such kyphos pads are quite as necessary with a plaster bed as with a frame since the plaster bed can only be carefully moulded to fit the kyphos in the first place and pads are necessary in order to apply a gradual and progressive correcting force The pads are first accurately fitted to the kyphos so that they hold and evenly control the whole area

of disease (but no more) at the same time protecting bony prominences from undue pressure Their surface area is not subsequently increased but an

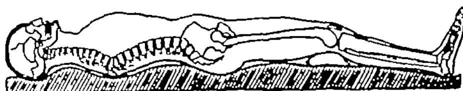


Fig 90 To show method of producing compensation of a kyphos. Note that the compensatory curves must be close above and below the initial deformity

additional layer of felt is placed between the pad and the plaster bed at a turning about once a week.

The Robert Jones spinal frame is designed to present a comfortable smooth surface for the patient's back (see Appendix) The abdomen and chest are

practically free and the patient can lie on the frame undisturbed for weeks or months But regular weekly turning is advised after the first two months in order to permit complete drainage of the kidneys but whenever the occasion arises for turning the patient on to his face a turning case is available This turning case (Figs 91 *a* and *b*) is made when the patient is

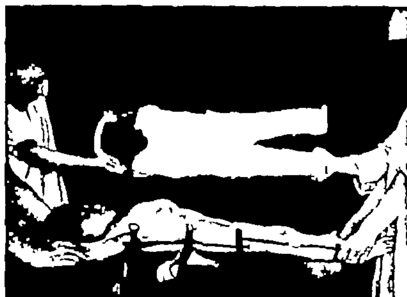


FIG 91 *a*.



FIG 91 *b*

FIGS 91 *a* and *b* Application of turning case. Note the excellent compensatory curves produced by padding the kyphos on the frame.

first put on the frame and is kept always available for the particular patient By this means turnings for inspection of the back for additions to the correcting pad for preparation for operation for the operation itself and for subsequent dressings are carried out without any interruption of the immobilization of the spine

The method is applicable to a frame or plaster bed which is free to be lifted but not applicable to complex plaster beds fixed to heavy wooden frames In the present work the authors have had to confine themselves so far

as the spine is concerned to a description of the Robert Jones spinal frame and the straightforward plaster bed Indeed they feel that these are universally



Fig 91 c



Fig 91 d

Figs. 91 c and d P tient lying in turning case Note the flat wasted spinal muscles the esult of prolonged immobilization on a frame in the supine position In the prone position compensatory curves will be produced and the spinal muscle redeveloped.

applicable and that once their management and turning are clearly under stood by the hospital team no difficulties are likely to arise

For special problems of nursing patients with paraplegia on frames or plaster beds see p 183

II Stage of arrested activity

This stage may be said to have been reached three months *after* the vario signs of a favourable general response have appeared such as

General 1 The absence of fever
2 The progressive loss of weight has changed to gain
3 An aspect of illness has changed to one of health.

Local. The local arrest is much more definitely assured when one ca detect radiological evidence of the arrest of erosion by clearer outlines an more normal calcification

Treatment at this stage differs in children and adults.

(*a*) *Children* A modification of the rigidly enforced immobilization in dors decubitus is now allowed The patient can be turned on to an anterior hype extension plaster bed The position assures a complete avoidance of flexio of the spine with associated compression strain on the bodies At the sam time there are the advantages of

(1) *the change of position after long dorsal decubitus*
(2) free flexion of the knees
(3) the free use of the erector spinae and the posterior muscles of th shoulder and neck, and
(4) natural drainage from the kidneys

Children thrive on such treatment and should be kept thus splinted unt the disease can be considered healed.

(*b*) *Adults* Since adults do not respond well to a very long period of im mobilization posterior spinal fusion is indicated when their general conditio has responded to treatment.

But operation although allowing the patient to get up earlier than woul otherwise be possible *must not be regarded as cutting short the period necessar for successful general treatment* Spinal fusion is always followed by at leas three months strict immobilization another month in bed and a furthe period of ambulatory convalescence. This fades into after-care i e a con sideration of home and working conditions climate and so on.

Fusion is indicated as a rule in adults because sound reconstitution of th vertebral bodies does not take place naturally Moreover grafting provide a strong internal splint which is in the authors opinion the best guarante against local recurrence of the disease But it will not prevent the occurrenc of disease elsewhere if general treatment has not been continued long enoug to ensure healing of the primary tuberculous adenitis

Spinal bone graft operation. Throughout this operation as in lamin ectomy the principle of continued immobilization of the spine is obeyed The patient is anaesthetized on the frame or plaster bed the turning case put in position strapped on and the patient turned The frame or plaster bed is then removed and the portions of the back away from the field of operation are covered with hot thickly padded sterile towels.

It is almost always advisable to have a localizing radiograph taken before

operation using a piece of metal opposite a prominent spine which is marked by a scratch on the skin (Fig 92)

It is usually wise to include the spines of one or two vertebrae above and below the diseased area

The incision is made slightly to the left side to keep the scar away from the prominent spinous processes and so that the motor saw may be used unhampered by retractors on the surgeon s side The skin flaps are then re



Fig 92 Localizing radiograph showing metal marker

flected the bleeding stopped and the skin edges towelled Then a continuous long central incision is made through the supra and inter-spinous ligaments traversing the summit of each spinous process This is facilitated by half grasping each process with toothed dissecting forceps as the knife passes over it The motor saw is then used to flake off either side of each spinous process This divides the spinous process into three parts an undisturbed central portion and two lateral portions which remain attached to the muscles A chisel or osteotome (about the same width as the laminae) is now used to separate these lateral flakes outwards together with the periosteum of the bases of the spines and laminae The resulting space is rapidly and firmly packed as it is opened up and so one passes up the spine on both sides The length of graft required is now measured with a probe but the packing is left in place

Grafts of the Albee type are now cut or have already been cut by an assistant from the tibia If there is no marked kyphos these grafts can be broad and straight but if there is much angulation to the kyphos either the grafts must be cut to fit the deformity or multiple very narrow grafts and flexible

grafts are used. The authors in such cases almost always use a pair of broad flexible osteoperiosteal grafts to cover the bundles on either side The grafts are held in place by strong chromic catgut suturing of the supraspinous ligament which brings the lateral flakes of spines into contact with the grafts.



FIG 93 This illustrates disunion of the graft at the point of maximum strain, an argument for the addition of a cross section of graft (H) between the spinous processes t this point as illustrated in Fig 94 a

Deep mattress sutures are employed at the top and bottom of the incision to make sure of holding down the ends of the grafts which show a tendency to spring out If one or more spinous processes are prominent they are nipped with bone-cutting forceps and bent to one side under the suture line

After the skin has been closed and the dressing applied the plaster bed or frame is placed in position, strapped on and the patient turned into the supine position. The turning case is then removed but its warm wool padding left for the time being undisturbed on the patient

The whole procedure takes between twenty and forty minutes and since the use of the motor saw has eliminated hammering causes little shock.

Variations of the above technique 1 *The H-graft*[1] This procedure was introduced by one of the authors (G R G) for use in two circumstances

(a) Where a short stout synostosis between two vertebrae is required in cases in which there is reliable evidence that the disease is confined to the adjacent surfaces of these two vertebrae

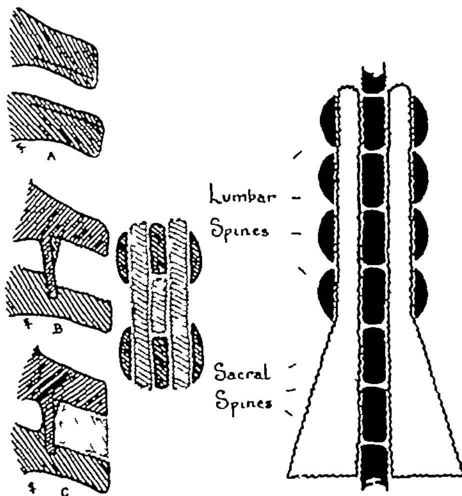


Fig 94 a. The H-graft. Fig 94 b Diagram of fish-tail grafting

(b) When on account of extensive destruction fracture-dislocation type very great strain will be thrown on the synostosis at a particular point which will be between the lowest spine of the upper segment and the highest of the lower segment A pseudarthrosis at this point is only too common and means that the main object of the operation has not yet been achieved The H method is of great value in providing great extra strength at the point of strain

2 *The one sided graft* If one is grafting for stability and there is at the

[1] Girdlestone *Proceedings of the Royal Society of Medicine* Nov 1932, 26 (Section of Orthopaedics).

same time the possibility of a future laminectomy being required it will be helpful to graft strongly on one side only i e the right For the performance of laminectomy some time after bilateral spinal grafting is very difficult and dangerous

3 *The lumbo-sacral graft (fish-tail grafting)* The difference in technique here consists in shaping the grafts in a special way These broad thin ends are so designed as to be placed on the back of the sacrum which has been prepared by Hibb s method of turning up multiple tiny osteoplastic flaps with a fine narrow chisel or gouge and hammer The upper part of each graft is of the ordinary Albee section The broad shallow end of the grafts placed on the rawed surface of the sacrum ensures a really strong fixation of this end which is otherwise liable to be precarious Furthermore the ordinary Albee graft is ill adapted to fit on the sacrum since it forms an awkward prominence under the skin which it may threaten to perforate

The preparation of the sacrum to receive the graft is always a delicate task as the dorsal plate is often very thin and sometimes incomplete. For this reason it is very dangerous to use a chisel blind on the back of the sacrum and the first step is carefully to expose the whole area of dorsal plate to be prepared First one side is exposed and packed, then the other One makes the most of such spines as there are then flakes up the dorsum as described

In addition to the modified form of Albee graft shown in the figures every form of osteoplastic technique is brought into action to suit the case in hand The preparation of the graft bed by the Hibbs technique is almost always adopted and found specially useful on smooth surfaces such as the back of the sacrum Where the antero-posterior space is limited broad osteo-periosteal grafts are used often covering a mass of cancellous bone seeds The surgeon has at his disposal many procedures by which he can build up his buttresses of bone his purpose is to produce a living union so designed in form and thickness as to carry safely the strains likely to be exerted upon it.

III Convalescence

The patient gets up when radiographs show that the disease is arrested and the region recalcified Adults can usually come off the frame or plaster bed three or four months after operative posterior spinal fusion they can then roll over in bed and should spend several hours each day in the prone position in addition to periods of erector spinae exercises When radiographs show satisfactory posterior synostosis and their dorsal muscles are thoroughly strong they can begin getting up for an hour or so But sun or air baths must not be given up or relaxed. This is the time to drive home the benefits of treatment and make them permanent! The period of hospital ambulatory treatment will vary with the home conditions to which the patient returns on leaving hospital The patient is first seen at the end of one month and then at gradually increasing intervals until the interval is one year Yearly visits are then maintained

The criteria for discarding the support and resuming work are the patient s

general condition X ray evidence of complete recalcification and of the strength of the graft and the nature of his occupation

Children when the prolonged conservative treatment which they need

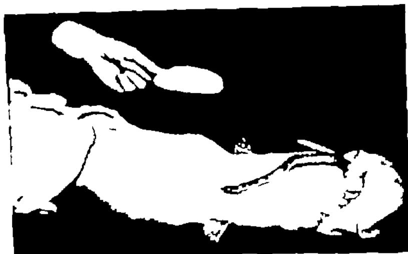


Fig 93 a



Fig 93 b

Figs. 93 a b d e Light spinal support. The patient has a severe but fairly well compensated dorso-lumbar kyphos. This is so prominent that a f lt pad, cut and grooved to fit it, has to be applied. Over this is placed the light spinal support which has been prepared on a plaster cast with a hollow over the kyphos but with its contour so arranged that when it is firmly strapped on the pelvis and resting on the kyphos the upper part stands away from the body

has led to the restoration of health and the production of reasonable orthopaedic stability coupled with recalcification are allowed up gradually with a support as for adults This support is worn for some years and even if considered advisable throughout the growth period

There is a proportion of cases in children over 8 or 10 in which spinal fusion

must be considered on account of instability In some the degree of destruction alone in others, a lateral displacement make a graft synostosis desirable as a safeguard before they leave hospital. In others one can wait and review



Fig 93 c



Fig 93 d.

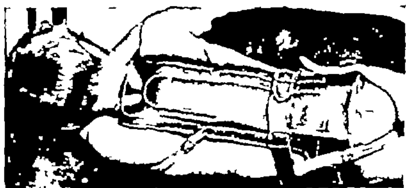


Fig 93 e.

the situation from time to time Spinal grafting in younger children is of far less value and hardly ever indicated

The convalescent splintage varies in type with the site of the lesion and in period with the age of the patient the extent of severity of the lesion and the protection afforded by grafting

Cervical upper and mid-dorsal region—spinal support with collar
Below mid-dorsal region—spinal support (see Figs 93 and 1~1)

N B In children if there is any lateral instability the support has moulded leather lateral wings stiffened by duralumin strips

Children wear their supports during the day till adolescence and then only remit them if there is really good spinal stability Adults after spinal fusion wear supports just as long as radiographs and clinical judgement indicate usually for at least six months oftener a year in order that the new bone may be trabeculated and its strength may be developed to meet all reasonable strains

Continued Grumbling Activity

The problem raised by grumbling disease has already been discussed in general (p 40) and in relation to the hip (p 102) a similar state is by no means uncommon in the spine Here again it is due to lack of stability in the lesion or of acquired resistance in the individual In children it is the lack of achievement of sound stability more often than any failure in health and vitality and almost always due to treatment which has been ineffective or insufficiently prolonged It is therefore the duty of the surgeon to satisfy himself as to the stability of the spine and to the adequacy of its protection for as long as necessary Posterior spinal fusion can play a great part in achieving this stability where there is any lack as a result of prolonged immobilization.

While kyphotic instability is the commoner lateral instability is just as prone to cause persistent grumbling activity Once deformity is established it is much better to correct it by compensatory curves above and below rather than to try and produce correction in the diseased area When compensation has been obtained it may be necessary to stabilize it by posterior spinal fusion

In the discussion of hip disease it was stated that liability to persistent activity of the disease was so nearly universal in the elderly that amputation was very often indicated there is no such possibility in spinal caries Here the best that one can do is to promote stability as quickly as possible by doing strong posterior fusion extensive enough to protect the whole of the diseased area and at least two vertebrae above and below in order to enable the patient to get up and about in security Old people do not stand prolonged dorsal decubitus without deterioration grafting should be carried out as soon as it can be properly undertaken and this may well be as early as two months after the beginning of treatment with a good routine of life the balance of rest and activity chosen to suit the health and progress of the patient he will be far better and far happier getting about with his spine protected by a graft than by lying in bed and losing ground. A remarkable example of the success of this line of treatment is given on page 285 (Mrs. H)

Severe Deformity

In young children caries tends to be very destructive and this may lead to severe deformity especially when three or more vertebral bodies are destroyed for over this area the growth of the somatic column is stopped. Deformity increases as the child grows that due to the original disease and destruction

becoming much exaggerated by the continued growth of the undamaged posterior and lateral elements of the vertebrae particularly the bilateral columns carrying the lateral articulations Ultimately there may result a degree of deformity which embarrasses respiration and is liable to set up another even more serious outcome—late paraplegia (see next chapter)



Fig 96 a.

Fig. 96. J W Case of extensive tuberculous destruction in the upper lumbar region associated with paraplegia, persistent grumbling activity and lateral angulation.

(a) X ray before grafting.

(b), (c), (d). After correction of lateral tilt and spinal fusion. This has resulted in recovery of the paraplegia and quiescence of the disease so far

Case J W

Developed Pott s disease in the lumbo-dorsal spine at the age of 3 years. She was under treatment in a sanatorium and at home for eight years and during the later years wore a support during the day but not at night. At the age of 14 her parents became distressed by the increase of her deformity She was admitted to the Wingfield Morris Orthopaedic Hospital (see Fig 96 a) and her treatment presented a difficult problem. The extreme lateral deviation was very gradually corrected on a frame with traction on the apparently short leg After holding the corrected position for six months the

traction was removed but the deformity rapidly recurred It was again corrected and posterior spinal fusion by broad doubl grafting carried out During the past eighteen months there has been no tendency to a return of the deformity and the disease has throughout remained quiescent (Fig 96 b)

While this is a case in which compensation has been produced with its resulting improvement in stability it is obviously much better to try and prevent the severe



Fig 96 b

deformity from occuring in those in whom it appears to be inevitable i.e. those in whom more than three vertebral bodies are completely destroyed. At this age the posterior fusion, however good, will be relatively plastic to strain and not strong enough to with stand unaided the strains likely to be imposed on it therefore she will wear a brace for several years, probably until growth has ceased and the quiescence of the disease is beyond doubt.

TABLE 8

Age Incidence Table

1–10	11–20	21–30	31–40	41–50	50+
61	44	99	53	4	19

This table of 319 cases f tuberculous spines includes both those treated conservatively and those treated conservatively plus operation.

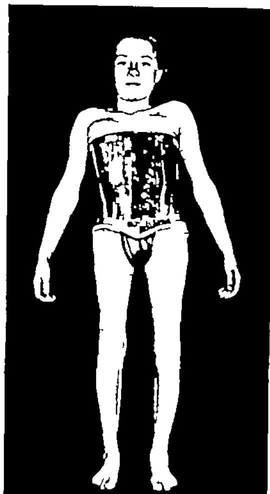


Fig. 96 c.

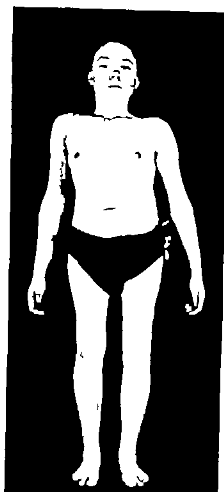


Fig. 96 d.

TABLE 0

Site of lesion		*No. of vertebræ involved*	
Cervical	13	Disc only	5
Dorsal	97	1	32
Lumbar	88	2	130
Sacral	1	3	66
D lumbar	63	4	16
L sacral	22	4+	19
Periosteal	1	Periosteal	3
		Double lesions	5
	287		278

The disparity between the two totals is due to 0 untraceable patients.

Table 10

189 Cases with Conservative Treatment + Operation

(a) Site of lesion

C	3	[illegible] per cent
D	56	30 ,,
L	59	31 ,,
S	1	0·50 ,,
D.L.	50	26
L.S.	19	10 ,,
No. not known	1	0·50
	189	100 per cent

(b) No. of vertebrae involved

Disc only	5	[illegible]0 per cent
1	18	10 ,,
	87	16
3	4	22
4	18	10 ,,
4+	6	3
Periosteal	1	0·50
Double lesions	4	
No. not known	8	4
	189	100 per cent

N.B. No. of vertebrae involved accurately recorded in 96 per cent
(a) shows the frequency of occurrence of lesions in the various regions of the spine
(b) shows the number of vertebrae involved at the time of the commencement of treatment

Table 11

Number of Vertebrae and Results

(Operative series continued)

No. of vertebrae	*No. of cases*	*Well*	*Unsatisfactory*	*Died*	*Incomplete*	*Untraced*
Disc only	5	3		1	1	
1	18	6	3	4	5	
2	87	4..	7	16	19	3
3	42	25	[illegible]	5	10	
4	18	1	1	1	2	2
4+	6	5				1

1 periosteal—not active—well.
4 double lesions 1 untraced.
1 well.
2 incomplete
8 no. not known.

Table 11 shows results as analysed in relation to the extent of the lesion

In referring to results no case is included in any group as a result that has not been followed reported on at least five years after the termination of active treatment. 'Well' means that the patient is able to lead a normal life without any complaint referable to the tuberculous lesion or its complications. Unsatisfactory includes all cases that have any residual complaint such as discharging sinus, appreciable degree of deformity, paraplegia, &c.

The mortality rate includes, as far as possible, only those who died as a result of the tuberculous lesion. There are, however, a few cases in which the cause of death could not be accurately determined, and these have been included. The mortality rate from the disease is, therefore, if anything, slightly lower than the figures indicate.

The cases classed as Incomplete are those who at the time of the analysis were undergoing

active treatment or were incomplete by reason of the fact that they were less than five years past the stage of active treatment

Untraced are those cases in which, either from our own records or with the help of the Tuberculosis Officer we had not been able to *determine the condition of the patient at least* five years after active treatment.

TABLE 12

Associated Lesions

(Operative series continued)

No. of cases	*Additional lesion*	*Results*
9	Pulmonary tuberculosis	3+meningitis (died) 1+hip (died) died, 1 incomplete, 1 lesion still active, 1 well.
5	Meningitis	1+renal (died) 1+epididymo-orchitis (died), 3 died.
2	Wrist	2 well and working
1	Renal	Died.
3	Knee	2 well and working, 1 incomplete
4	Hip	2 well and working 1 unsatisfactory 1 incomplete
1	Trochanter	Unsatisfactory
1	Shoulder and epididymo-orchitis+peritonitis	Died.
1	Ilium-amyloid	Died.
1	Foot-tarsus	Well and working
2	General tuberculosis	2 died.
1	Orchitis	Died.
2	Ankle	1 well and working, 1 untraced
1	Elbow	Unsatisfactory

N.B 34 cases with more than 1 lesion out of a total of 189

Table 12 shows 34 of the operative series of tuberculous spines which were complicated by other active lesions. The frequency of occurrence of the additional lesions are shown and also the results of treatment.

TABLE 13

(Operative series continued)

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Total*
Well and working	29	19	40	24	7	5	124 — 63 per cent
Untraced	2	2	7	4	0	0	15 — 8
Incomplete	6	1	5	1	1	1	15 — 7
Unsatisfactory	1	0	3	1	2	0	7 — 4
Died	3	1	1	5	5	2	28 — 10
	41	23	67	35	15	8	189 — 100 per cent.

Table 13 shows results in 189 cases in which operative procedures were an integral part of treatment. Only laminectomy or costotransversectomy and spinal fusions have been included as forming an integral part of treatment

The age indicated is that at which the patient was first seen and only approximately 10 per cent. of the first group were operated on *before 10 years of age.*

Table 14

130 Cases with Conservative Treatment only

(a) Site of lesion

C. =	10 =	7·50 per cent.
D. =	41 =	3[illegible] ,,
L. =	20 =	22
S. =	0 =	0
D.L. =	15 =	1[illegible]
L.S. =	3 =	[illegible]
Periosteal =	1 =	0·50
No. not known =	31 =	[illegible]4
	130 =	100 per cent

(b) No. of vertebrae involved

1 only =	14 =	14 per cent
2 =	43 =	44
3 =	[illegible] =	[illegible]
4+ =	13 =	14
Periosteal =	2 =	
Double lesions =	1 =	1
	97 =	100 per cent.

N.B. In approximately 80 per cent. of these cases is the extent of the lesion now accurately available.

(a) shows the frequency of occurrence of lesions in the various region of the spine.

(b) show the number of vertebrae involved at the time of the commencement of treatment.

C. = cervical. D. = dorsal. L. = lumbar. S. = sacral. D.L. = dorso-lumbar. L.S. = lumbo-sacral.

Table 15

No. of Vertebrae and Results

(Non-operative series continued)

No. of vertebrae	No. of cases	Well	Unsatisfactory	Died	Incomplete	Untraced
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	14	50		29	7	14
2	43	55	5	23	9	7
3	24	30	4	33	12	21
4	13	54	15	7·5	7·5	15

Table 15 shows results as analysed in relation to the extent of the lesion.

Table 16

(Non-operative series continued)

No. of cases	Additional lesion	Results
9	Pulmonary tuberculosis	7 died, 1 well, 1 unsatisfactory
4	Meningitis	Died.
5	Miliary tuberculosis	Died.
3	Peritonitis	Died.
	Ankle	Well.
2	Knees	1 died, 1 well and working
2	Hips	1 died, 1 unsatisfactory
1	Great trochanter	Well.
1	Shoulder and elbow	Untraced
1	Elbow	Well.
1	Symphysis pubis	Well

N.B. 31 cases with more than 1 lesion out of total of 130.

Table 16 shows 31 of the cases of tuberculous spines (treated by conservative measures alone) which were complicated by other active lesions. The frequency of the occurrence of the additional lesions are shown and also the result of treatment.

TABLE 17

(Non-operative series continued)

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Totals*
Well and working	23	10	18	7	6	5	69 = 53 per cent
Untraced	3	2	1	3	0	0	9 =
Incomplete	8	1	0	0	0	0	9 =
Unsatisfactory	0	1	4	0	1	0	6 = 5
Died	6	7	9	7	2	6	37 = 8
	40	*21*	*3*	*17*	*9*	*11*	130 = 100 per cent.

Table 17 shows results in 130 cases in which conservative measures only were used and these are classified into age periods.

CHAPTER VIII

POTT'S PARAPLEGIA

PARAPLEGIA occurs in about 10 per cent of all cases of spinal caries, an is much more common in the thoracic spine than elsewhere indeed in published series[1] the lesion was located in the thoracic spine in 157 out c 186 cases Unfortunately there is a great deal of misunderstanding as to th proper treatment of this most threatening complication and this has led t undue conservatism whereby many patients have needlessly been allowe to suffer permanent paralysis with its distressing and ultimately fatal sequelae It is even now widely regarded as correct to persist with conservative treat ment for six months despite increasing damage to the cord with its associate dangers and discomforts, because operative decompression has been mos unfairly discredited It is high time that a true balance should everywher replace the dangerous bias in favour of conservatism that followed the tw admirable essays by Butler and Seddon in 1935 for unfortunately th truth did not emerge from their statistical review of operative decompre sion The relatively good results of the relatively few well-chosen well timec and well performed operations for decompression were mixed with man disastrous results of operation carried out without adequate orthopaedic pre cautions These disasters were due to the destructive effect on the cord itse and on the evolution of the vertebral disease inevitably associated with the operations without the safeguard of accurate and uninterrupted immobiliz tion of the spine maintained before during and after their performanc Anaesthesia entails the loss of the protection of dorsal muscular contro Anaesthesia and operation in the presence of paraplegia without continuo accurate splintage of the spine is even more dangerous Thus decompressio was condemned because of the many terrible results Butler wrote to one of th authors in 1937 It astonished us and I know it would astonish you to fin how lightly laminectomy was carried out in many patients in our series (ofte in the presence of active disease) without really adequate care at the time, afterwards to preserve mechanical efficiency in the spine as a whole Indee both these authors recognize the misleading nature of the statistics the gathered from miscellaneous sources and are in agreement as to the dang of undue delay in decompression of the spinal cord.

As an instance of the degree to which the unfortunate influence of the figures is still at work can be quoted recent figures from a first-class orth paedic hospital giving a series of 118 cases of paraplegia in which decompre sion was carried out in only sixteen

It is of course wholly right to condemn decompression in Pott s parapleg

[1] Butler R W., Paraplegia in Pott s Disease with special reference to the Pathology ar Etiology British Journal of Surgery 22, no. 88 1935.

unless it is done by surgeons experienced in spinal tuberculosis and with the maintenance of effective and uninterrupted immobilization of the spine before during and after operation Such protection was made possible by the addition of a turning case (Figs. 91 *a* and *b*) to the frame or plaster bed more than thirty years ago in Shropshire The use of some such continuous control has been the practice in the best orthopaedic centres for many years, and has altered the whole situation. One should note however at this point that the complete control of the spine, with the protection of the diseased vertebral bodies depends on the integrity of the lateral articulations. The importance of this will be apparent when we discuss the lateral approach to the spinal theca

We can therefore assess the indications for operative decompression by costotransversectomy or laminectomy (without facetectomy) free from fear of endangering the structural stability of the spinal column but we are still face to face with a very serious and dangerous complication of a disease—very serious and dangerous in its own right

Two main groups can be distinguished by their onset being early or late in relation to the disease of the spinal column

A Early associated with the primary activity of the spinal lesion.

B Late after—sometimes long after—the disease has apparently been arrested and the patient has left hospital.

This second group contains two subdivisions in that the paraplegia may be due either to (1) recrudescence of disease or (2) to the slow progressive deterioration of the cord caused by the derangement of its relations within the vertebral canal.

Group A

Paraplegia often arises quite early in the disease indeed, in adults, some awkwardness in walking due to inco-ordination and spasticity is not uncommonly the first arresting symptom see Case C.M. p 195 This is seldom so in children both because paraplegia appears relatively late and because the caries is discovered earlier More attention is paid to backache in children than in adults Indeed, paraplegia in children is becoming very rare in many places on account of early diagnosis and effective treatment.

Group B

(1) **Unsound healing** Recrudescence of disease In this group paraplegia may occur a year or even less after a patient has been allowed to get up The healing has been unsound and has given way before the pressure of body weight and strain of movement The risk of paraplegia from pressure associated with an insidious recrudescence of disease is, indeed run by every patient who is allowed to get up after an inadequate period of decubitus or with inadequate protection This furnishes an argument in favour of operative

posterior fusion whenever there is any doubt of the stability of the spine after the arrest of a lesion

(ii) **Great deformity** The other group is of much later and more insidious occurrence and is associated with long-continued extreme angulation of the column

In some of these cases (B ii) the cause is comparable to that which operates in the paraplegia of scoliosis where the symptoms seem to be due to a prolonged stretching and dragging of the cord against an irregular and angled bony bed, coupled with the varying strain transferred to the cord by flexion of the head and neck above or by the pull on it from below via the sciatic nerves and associated with changes in posture This group is distinguished by a complete absence of any clinical signs of tuberculosis or radiological signs of compression

THE CAUSES OF PARAPLEGIA

1 Oedema

There is considerable evidence of the existence of an early form of paraplegia due to a change in the circulation of the cord in the neighbourhood of the lesion without gross compression This is generally associated with the early and most active stage of the disease when there is vascular engorgement infiltration lymphatic obstruction, and as a rule some mild circumferential compression The paraplegia is transient and as quickly relieved by immobilization as is the transient arthritis of the hip.

2 Compression

From in front

(i) By abscess, which by tracking backwards is producing extradural compression of the cord. This condition is generally associated *with radiographic evidence* of a tightly distended pre- and paravertebral abscess (see Fig 63 p 121)

(ii) By a granuloma or a collection of débris (or both) developing in the extradural space behind the spinal column *without radiological signs.*

(iii) By bone (*a*) by pressure from a sequestrum, which has been pushed backwards by the increasing angulation

(*b*) Pathological fracture-dislocation.

(*c*) Extreme angular kyphos

From behind By a granuloma or a collection of debris associated with disease of the ring rather than the column i.e lateral articulations pedicles or laminae often with *little or no visible radiographic abnormality*

THE MARCH OF SYMPTOMS AND SIGNS

If the patient is up and about the first symptoms of paraplegia are commonly stiffness and awkwardness of gait. The legs get more spastic and uncontrollable until the patient is confined to bed This may help to arrest the

progress of the paraplegia otherwise sphincter disturbances follow and about this time alteration in sensation can be detected If the patient is in bed or with the spine already immobilized weakness and awkwardness in the movements of the feet are noticed. Such is the usual progression, because the cord is most often compressed from in front

At first the spastic limbs lie extended but if the pressure is severe or long maintained painful flexor spasms appear producing the full picture of paraplegia in flexion which indicates a complete loss of conductivity of the pyramidal tracts. In very exceptional cases the compression is sudden enough to cause an initial flaccid paralysis from spinal shock (Case H L.) (Fig 104)

Urinary sepsis and pressure sores are common and very serious complications.

PROGNOSIS

Group A

In Group A the paraplegia is directly associated with active tuberculosis nevertheless the activity of the disease and its neurological complication are not fully interdependent for the paraplegia may yield though the tuberculosis proves fatal, or on the other hand the tuberculosis may heal and the paraplegia remain. Of what value to most of us is life with permanent paralysis? To be alive and remain paralysed is doubtfully preferable to death from tuberculosis after recovery from paralysis![1]

Actually the surgeon must accept more direct responsibility for paraplegia than for death since he can almost always avoid permanent paralysis but cannot always promote immunity In Group A though the paralysis is often complete if the patient is seen in good time the paralysis is curable provided that the tuberculosis can be arrested There are very rare exceptions to this rule of which an example is described by Seddon [2] Other factors influencing prognosis are as follows

1 The age of the patient

It is the authors opinion that both the prospect of life and of recovery from paraplegia is better in the young than in the old.

2 The duration of the paraplegia

It is safe to say that the longer the paraplegia has existed the less likelihood there is of recovery either by conservative or by operative treatment

In Seddon's[3] series 13 recovered after 3 months total motor paralysis 11 after 6 months 3 complete and 1 incomplete recovery after 9 months 2 after 1 year 4 complete and 3 very incomplete recoveries in the second and subsequent years He says the chances of complete recovery from total motor paralysis of more than 6 months' duration are extremely poor.

[1] Percivall Pott (F R.S) 1779
[2] Seddon, British Journal of Surgery April 1935 22 no. 88, p. 774
[3] Loc cit

On the other hand the authors feel very strongly that a patient who has been completely paralysed by a compression form of Pott s paraplegia and who has for some unhappy reason been allowed to remain completely paralysed for many months ought to be given the chance of recovery however slight offered by relief from compression under conditions of uninterrupted immobilization

In late-onset paraplegia Butler has drawn attention to the association in his series of a high protein figure in the cerebrospinal fluid with a good prognosis This would support the authors belief that the paraplegias which are due to extra thecal recrudescence of the disease are more susceptible to treatment and more recoverable than those associated with the intrinsic changes within the cord following long-continued severe angulation of its bed

TABLE 18

Protein of the Cerebrospinal Fluid in Late onset Paraplegia in Relation to End results of Treatment

Serial number of patient	*Persistence of paraplegia prior to cat mation*	*Prote n in cerebrospinal fluid**	*Result of further conservat ve treat ment of the paraplegia as for act ve tuberculous disease of the spine*	
	Months	*Gm per 100 c.c*		
(S) 58	4	0-9	Recovered	
(B) W.N	4	0-4	Recovered	
(B) D.S	1	0 3	Recovered	
(S) 63	1	0- 4	Recovered	
(B) F C.	3	0-15	Recovered	
(B) J.B	1*	0 1	Recovered	
(S) 99	10	0-1		No recovery
(S) 22	2	0 08	Recovered	
(B) J.D	10	0 06		No recovery
(B) E.B	6	0 03		No recovery
(S) 97		0 03		No recovery
(S) 3*	24	0-015		No recovery

* Normal 0-01–0 03

3 The nature of the paraplegia

(*a*) **Motor loss** The deeper the motor paralysis the less favourable the prognosis. Partial paralysis is more favourable than complete paraplegia in extension, which indicates an incomplete pyramidal lesion while this is far more hopeful than paraplegia in flexion which means the complete loss of pyramidal conduction. Worse still is flaccid paralysis but even this is not necessarily hopeless (v Case H L.) And operation by one of the authors in a case of prolonged paralysis in flexion was followed by partial recovery which was of the greatest benefit to the patient (v Case H.B) The intensity and the duration of the compression must be the factors which determine whether or not the cord can recover and the intensity of compression in Pott s disease is very rarely in any way comparable to the mortal crush of a fracture-dislocation

(*b*) **Sensory** The more complete the loss of sensation below the lesion the more unfavourable is the prognosis the motor tracts bear the brunt of the pressure except in the rare instances of pressure from behind

(*c*) **Sphincter control.** This loss too indicates greater pressure and for that reason a less favourable prognosis.

It is easy to be unduly depressed by a list of unfavourable signs and symptoms and to adopt too gloomy a view with regard to the patient who presents them Pressure on the cord which has developed gradually is far less harmful than a sudden crush It is true that pressure severe enough to cause loss of all motor power sensation and sphincter control is naturally more harmful than less pressure but so long as pressure develops gradually it is not only its degree but also the length of its duration that makes for irreparable harm Total loss of conduction due to gradual compression by no means carries a hopeless prognosis but there is no time to lose!

4 The illness of the patient

Apart from the above points the signs of active tuberculosis in general, of persistent activity of the local focus in spite of good general and local treatment or the presence of a secondarily infected discharging sinus are of course very unfavourable features.

5 The treatment

Early diagnosis and prompt effective general and local treatment of the spinal tuberculosis make the onset and serious advance of paraplegia very rare But if it does develop the authors believe that the prompt effective treatment of the disease coupled with skilful treatment of the paraplegia and if need be operative relief of the cord from pressure without undue delay will, with the rarest exceptions eliminate the tragedy of permanent paraplegia The most important variable factor is the quality of the treatment

DIAGNOSIS

The diagnosis of Pott s paraplegia in cases where the paraplegia itself brings the patient to hospital is the recognition of spinal tuberculosis as the basic cause (see p 120) In most cases the diagnosis is clear from the history clinical examination and radiography for as a rule the radiographs are characteristic of spinal caries but X ray signs may be anomalous or even absent Evidence of erosion is absent or very difficult to detect when the disease is mainly subperiosteal, or affects the posterior surface of a body or some other part of the vertebral ring The development of pressure on the cord from a posterior subperiosteal granuloma or abscess without radiographic signs gives rise to the so-called spinal tumour syndrome The diagnosis of tuberculosis as the underlying cause then depends on other evidence but if the paraplegia is severe with a positive Queckenstedt test and adequate localization, surgical decompression is indicated without delay for rest in extension or hyperexten

sion does not relieve paraplegia in the spinal tumour syndrome Sometimes it may be difficult to decide especially in older patients whether the under lying disease is tuberculous or malignant

Localization of the compression

The evidence of neurological examination and radiography commonly com bine to localize the compression If a tense paravertebral abscess is shown



FIG. 97 F.C. Woman aged 26. Hump on back and early signs of paraplegia noticed within three months of an apparently normal confinement. X ray and operative findings show pathological dislocation.

coinciding with the level of the neurological lesion it is evacuated by costo-transversectomy without need for further localization so too when there are clear radiographic indications for laminectomy But when the X ray evidence is less conclusive it is always advisable to carry out Queckenstedt s test in order to prove compression, and incidentally to obtain cerebrospinal fluid for examination

With this proof of compression and thorough neurological examination

localization is usually fairly exact but if the signs are equivocal lipiodol may come under consideration, particularly as accurate localization is very desirable in tuberculosis in order to minimize the field of the laminectomy But on the other hand one must bear in mind that opening the theca is generally undesirable in this condition, and may be strongly contra indicated thus the lipiodol will remain and may later give rise to root pains There is however little fear of this if the best quality (spinal) lipiodol is used and if it is tested for colour by comparison with a tube of poppy seed before injection.

TREATMENT

The prevention of paraplegia in Pott s disease can be largely achieved by the early diagnosis of spinal caries and its prompt effective treatment. Some cases will still arise some of them with signs and symptoms of paraplegia as their first complaint In every case the first step is immediate admission or transfer to a first-class orthopaedic centre where there is every facility for open-air treatment for orthopaedic care and for operation under the best circumstances by a surgeon skilled and experienced in spinal tuberculosis. *Here the decision between conservative and operative treatment will be* reached on the following groups and if operation is postponed the decision is reviewed from week to week.

Group A One can rely upon a natural recovery with good general and good local conservative treatment when the motor paralysis is not complete sensation is intact and some control of the sphincters retained particularly when there is no radiological evidence of a tight paravertebral abscess

For example a boy of 15 comes in with a slightly spastic gait There are radiographic signs of caries in the mid-dorsal region but no obvious para vertebral abscess This patient is put on a spinal frame in full extension with a moulded pad over the kyphos In such a case the paralysis might be expected to diminish progressively starting within a few weeks and if this was borne out one could be confident that the cure would be complete

On the other hand the prognosis is different in a second type say that of a woman aged 23 with a complete motor paralysis in extension and with radiographic evidence of a tight paravertebral abscess together *with mutual erosion* of two mid-dorsal vertebrae There is a history of advancing spasticity for the previous two months and the patient looks ill She is immediately put on a frame or *if the kyphos is too severe on an accurately fitting plaster bed* with kyphos pad In such a case can one rely on natural recovery within a reasonably short time? Is it not probable on the other hand that for a period at *least the debris of destruction will accumulate* and since the paravertebral abscess is already tensely distended will cause increasing pressure on the cord? In such a case the authors feel that the prognosis without operation is dubious and that every day s delay increases the damage to the delicate structures of the cord and makes it more likely that this damage will be partly or wholly irreparable In such a case their practice is to carry out costo-

transversectomy as soon as the patient is comfortably settled on her frame and improving in general condition

Let us take a third example from Group B of a woman of 40 with complete loss of conduction motor sensory and sphincter Her spinal tuberculosis was discovered late she had already much local bone destruction with marked angulation and pathological dislocation but there was no sign of a paravertebral abscess. The prognosis without operation was exceedingly poor Even with operation there was little hope Yet the good result in this case (H B p 197) shows that relief may follow decompression even when the neurological picture is most unfavourable Operation was undertaken only because the woman s existing circumstances were so unhappy that she was most anxious to be given any chance of benefit however small

Group B Here we have to deal with two quite distinct groups of cases

(i) Those due to compression

(ii) Those due to long-continued deformity without compression

Here an analysis of the cause is obviously the first step exactly on the lines adopted for Group A followed by treatment on the same lines.

In both subgroups we have to deal with a number of very severe deformities In such cases the radiological work is difficult but of most critical importance Stereoscopic lateral radiographs of the highest quality are necessary and we ask of them a clear view of the boundaries of the spinal canal both in order that we may see whether there is evidence of recrudescence of disease and so that we may visualize the spinal cord as it lies against the anterior wall of the canal, at the apex of the kyphos formed by what is left of the bodies with perhaps a ridge of bone or prominent sequestrum (Figs. 98 and 99) In those cases in which there is no severe deformity no ridge or sequestrum to be seen in the lateral view we examine the A.P stereos for evidence of a tense abscess Lumbar puncture the examination of the cerebrospinal fluid and Queckenstedt s test give further information Here again as in Group A the surgeon must discover pressure and take steps for its relief by conservative means if the clinical picture allows the time without risk or harm to the cord but by operative means without delay when delay would involve risk of permanent neurological damage For the reasons mentioned the authors do not agree with Butler in saying

> The only real test of ability to recover is to put the patient under treatment by fixation in recumbency as for active (persistent or recurrent) tuberculosis of the spine and await results, whether such disease is clinically present or not With the passage of time Type III paraplegia is then found to fall into one or other of two sub divisions
>
> Type IIIa Late onset paraplegia recovering on conservative treatment as for active tuberculosis of the spine
>
> Type IIIb: Late onset paraplegia not so recovering

Butler reports 96 cases of which 58 recovered 38 did not The authors are not in agreement with this policy of uncritical expectancy They recommend

an early analysis of each case in order to discern as clearly as possible the cause of the paralysis followed by a careful assessment of the value of operation whether decompression or synostosis Synostosis diminishes the accumulation of debris by eliminating the grinding movement of respiration, and in so doing favours the arrest of the disease

In regard to the B group Butler has drawn attention to the association in his series of a high protein figure in the lumbar cerebrospinal fluid with

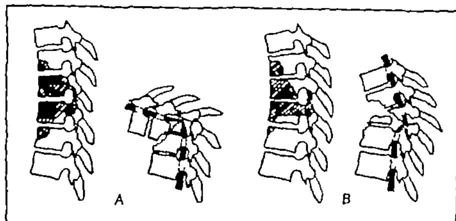


FIG 93. Diagrams showing two ways in which pinching of the cord may result from pathological dislocation from Pott's disease in the thoracic region. The shaded areas are those in which bone is destroyed.

A The upper segment of the spine has slipped downwards and forwards.

B The segment has slipped downwards and backwards.

good prognosis (Table 18) This would support the authors belief that the paraplegias due to recrudescence of disease are more susceptible of treatment, and more recoverable than those associated with the late mechanical effects of severe angulation.

Timing of operative decompression

When the paresis is mild or moderate and of recent appearance a period of conservative treatment favours the patient's reaction to the disease and allows repeated observation of the neurological signs. How long to wait is often difficult to decide and calls for a careful balancing of the neurological and general clinical picture

We should never forget the long lag between the cessation of activity and the relief or even diminution of pressure It is no longer excusable to allow continued compression of the cord when the damage is each week becoming more irreparable to allow further pressure to develop perhaps to watch progressive exhaustion from painful spasms and to let the urinary system become infected Decompression may now be indicated even during the active stage of the disease for the continuity of immobilization has swung the balance in favour of operation and one can aim at earlier relief of the cord without fear of aggravating the local tuberculosis.

In cases in which there is evidence of severe or progressive compression it may be advisable to operate without more delay than is required for settling the patient on frame or plaster bed and providing a good turning case In such circumstances one operates because the relief of the spinal cord appears of such urgency that it is unwise to allow time for conservative treatment to exercise a favourable effect—*qua* disease and perhaps also *qua* paraplegia This justifiably contravenes the golden rule that it is wrong to perform

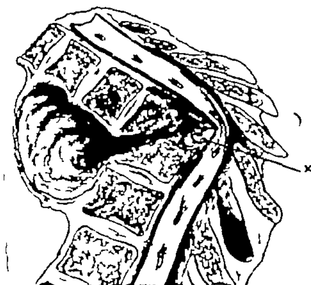


FIG. 99. Drawing showing pathological dislocation of the thoracic spine in Pott s disease with pinching of the cord The upper segment of the spine has fallen downward and forward over the lower so that the bone compressing the cord is the persisting postero-inferior corner of a vertebral body which has remained in position, forming the apex of the lower segment.

a major operation on a patient who is still subject to the active invasive stage of skeletal tuberculosis—a golden rule because such a patient is ill fitted to stand shock, which is an immediate danger to his life and a set back to his body s attempt to put up a successful fight against the disease Furthermore at this stage the body s immunity is at its weakest and there is risk of the dissemination of tuberculosis from the escape during or after the operation of infected material into veins or lymphatic channels As time passes provided that the total response of the patient is favourable operation carries less and less risk, so that when the phase of successful reaction has been established the danger of dissemination is almost nil.

A decompressing operation for a mild or even a moderate degree of Pott s paraplegia is not then ordinarily indicated until the patient has been for a period given the benefit of good general treatment in the open air coupled with effective immobilization of the spine It is true that G L. Alexander has

recently written The indications for decompression of the cord in Pott disease are we think no different from those in cord compression from othe causes But this disregards contra indications and we prefer to balanc the indications and contra indications very carefully in each case with du regard for the patient s life and an even greater regard for the restoration o the function of his spinal cord. We say this because we believe that mos patients would choose to run the risk of early operation if it favoured th recovery of the cord but even more because we believe the decompressio (by the skilful and gentle performance of one or other of the operations) i likely to be of great indeed critical, value to the cord and do relatively littl harm to the patient

With regard to the preliminary period of conservative treatment, si months has been suggested, but we are sure that this is much too long, ever in mild or moderate paraplegia and would operate in six weeks or less if there were no encouraging signs of improvement. Furthermore in severe or ad vancing paraplegia the time soon comes when further delay is bad not only for the patient s spinal cord but for his mind and body too All are now deteriorating There is no excuse for further inaction

In order to favour the management of this complex syndrome all cases in which Pott s paraplegia develops should be sent at once to a first-class ortho paedic centre where special nursing skill and all facilities for open-air treat ment and expert immobilization exist and where mature judgement and operative skill are always available

Choice of operation

In this brief review it has not been possible to discuss pathology at any length there has been an excellent review by Seddon. But when the choice of operation is to be made a great deal depends upon whether the paraplegia is associated with active disease or apparently the result of long continued cumulative effects of deformity at a much later stage We must also omit any discussion of cases in which the disease affects the posterior parts of the vertebral column.

In paraplegia associated with the active phase often called early para plegia the compression is commonly from in front and generally associated with the dissolution of the somatic column amounting to what has often been called pathological fracture This means a gap in the column through which the debris and pus resulting from the destructive processes may pass and collect in front to the sides or behind the bodies. Therefore in cases where radiograms show evidence of a large taut paravertebral abscess it is obviously foolish to do a laminectomy (Figs. 100 *a* and *b*)

In such a case costotransversectomy with complete evacuation of the abscess will often suffice especially where there has been time for the destruc tive process to become arrested as a result of general and local treatment It may have to be repeated in preference to laminectomy on radiological evidence It can always be followed by laminectomy and grafting through

another route if after three or four weeks there is no evidence of relief (Figs 102 and 103)

By this means decompression can be achieved without any interruption of the series of bilateral articulations which, with the control of antero-posterior splintage, protect the diseased bodies Costotransversectomy and laminectomy (without facetectomy) either one or both in series have no

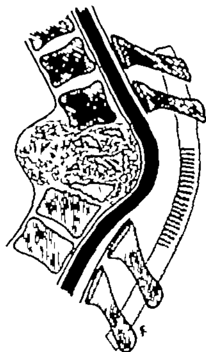


Fig 100 a C.M. 28.1.1 Diagrammatic representation of state of affairs immediately after laminectomy which was followed by recovery within 1 hours.

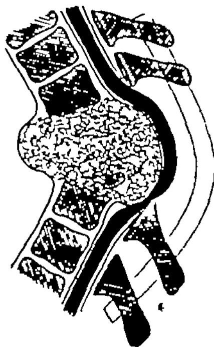


Fig 100 b C.M. 1.6.1 Recurrence of paraplegia. The original indication was for costotransversectomy rather than laminectomy

harmful effect on the stability of the spine under standard modern orthopaedic care This is often imperfectly understood and laminectomy has been falsely accused even quite lately by Alexander Yet this fact is of fundamental importance in regard to the choice of operation for early paraplegia

The nursing of a paraplegic patient

First comes the need for complete immobilization and in order to ensure this for a much more stringent yet protective form of splintage than suffices for uncomplicated spinal caries In practice this may involve the complete enclosure of the lower limbs in plaster for anything short of this may fail to cut out the flexor spasms This advice is given with full knowledge that it used to be taught and perhaps still is that to enclose insensitive limbs in

plaster was thoroughly wrong on account of the liability to the development of pressure sores perforating because painless The relief given from the distress and weariness of flexor spasms is very great and the method is safe *with two provisos regarding the plaster technique* and the subsequent watchful care The technique was worked out at Baschurch by Miss Hunt The patient s lower limbs are first firmly and very evenly bandaged over a thick wrapping of cotton wool, then over this is placed a further layer of wool and finally the plaster of Paris is most evenly applied and carefully moulded. This is the first point—the stringent yet protective immobilization the second point concerns a careful watch upon the patient All spasms should *disappear in twenty four or forty-eight hours as a result of the immobiliza*tion together with the complete elimination of any sensory stimuli from the skin Any continuation of spasms means either that the immobilization is incomplete, or that there is some point of pressure sufficient to excite reflex spasms this calls for the *immediate* removal of the plaster in order to find and eliminate the point of pressure for it will otherwise quickly bring about a sore.

After a successful application the spasms are lost the patient is at rest comfortable by day and sleeping well at night but a most careful watch must still be kept up The nursing staff must understand that the warning symptoms of a sore will be represented by a brief reappearance of spasms, or even just a little restlessness at night and perhaps only for one night! It is, indeed essential to recognize that the warning is of short duration. The reflex spasms result from irritation of the sensory nerve endings in the skin, and this occurs *only during the few hours when the pressure is enough to redden and irritate* the skin, but not to deaden and perforate it The reflex spasms are reinitiated by this irritating pressure on the skin but if the pressure continues, the irritation soon ceases because the sensory end-organs are cut out Therefore unless immediate action is taken and the whole plaster removed on what to the uninitiated would appear a negligible symptom the skin is penetrated and a deep pressure sore develops

The success of a hospital in preventing the development of pressure sores in these difficult cases and indeed in all the many cases on plaster beds or on frames depends on the alertness of the probationer nurse to observe and to record with emphasis a hint which unless so emphasized appears trifling and may fail to arrest attention For the smallest change from rest to restlessness may be the only warning of what will quickly and silently become a deep and septic sore It is for the nurse first to notice a return of spasms or a little restlessness then to enter the matter in the night report and in some way to draw attention to the significance of her observation

The bladder

Interference with bladder function always involves a decision as to whether the bladder should be drained suprapubically by tied in catheter or by repeated catheterization The bladder receives sympathetic supply from

Lumbar 1 and 2 cord segments This relaxes the detrusor and closes the sphincter The parasympathetic supply is from Sacral 2 and 3 This contracts the detrusor and opens the sphincter therefore if the lesion of the cord is above cord segment Lumbar 1 it is reasonable to expect the development in the course of a few weeks of a cord reflex capable of emptying the bladder periodically i.e an automatic bladder If on the other hand the sacral segment of the cord has been crushed at the level of the 1st lumbar vertebra the parasympathetic innervation is lost and automatic bladder function cannot develop because the sympathetic is unopposed In these cases early suprapubic drainage should be instituted and the bladder irrigated from the urethra and out through the suprapubic tube Prolonged use of a tied in urethral catheter has drawbacks in that it often sets up urethritis with ascending complications Regular periodic catheterization with all aseptic precautions including handling the catheter with dissecting forceps only is safe in these cases even for a prolonged period

Operative

It need hardly be repeated that the basis of treatment of all cases of Pott s paraplegia is immobilization and general treatment for tuberculosis that in some this is the only treatment that will be required but that in others recovery from paralysis can only be attained by operation The field for operation is wider and its benefit greater now that the indications for one or other method of decompression are recognized, and the chosen operation performed without risk of straining the diseased spine or impairing its stability There is a tremendously strong argument for early spinal decompression in selected cases if it can be accomplished with reasonable safety as indeed it can In what percentage of recoverable paraplegias the compression factor is gross it is impossible to state Even when it is severe however it would seem likely that its relief gives the best prospect of restoration of the function of the cord and a very good prospect provided that the compression has not been too long maintained The authors attitude therefore is to look very critically upon all cases of paraplegia with clear ideas as to the indication for operation.

When the patient has been accurately and comfortably immobilized on a spinal frame or plaster bed and the turning case made ready the points for and against operation must be considered If the patient is reasonably fit and well one is free to operate soon. On the other hand if the patient is ill a preliminary period of rest and general treatment is very desirable But even so one may be driven to a compromise between premature operation from the point of view of the patient and delay which may prejudice the recovery of the cord In such cases the threat to the viability of the cord and the dangers of the complications of severe paraplegia must be balanced against the poor or incomplete reaction of the patient

The next consideration concerns the relationship between the onset and duration of the paralysis and the period and efficacy of the immobilization

One must clearly not operate on a patient whose paraplegia is relatively mild who has not been adequately immobilized and in whom there is no tense paravertebral abscess On the other hand the authors would advocate operation in a case where the paraplegia was complete and a tense paravertebral abscess was present whether there had or had not been adequate immobilization. Between these two types there is a great variety of clinical pictures and the decision will often call for much thought and very careful study of first class stereoscopic radiographs

In one case the surgeon may decide to postpone operation on account of what may be termed a non reactive condition in another he may feel that the patient is in for a long period of smouldering disease and that to wait for a natural improvement would be to allow the cord to suffer irrecoverable damage The authors feel that on the whole it is better to operate on a certain number of cases that would perhaps recover without operation than to run serious risk of permanent irreparable damage to the cord through hesitation and delay

In the absence of radiological evidence of pressure the authors would most carefully watch progress and generally arrive at their decision during the first month occasionally the decision might be postponed for a second or even a third month following the onset of paraplegia To wait until six months have passed is clearly disastrously wrong! For the delay may allow the initial damage to become irreparable a disaster avoidable by reasonably early radical relief

Paraplegia becomes permanent and irreparable because the pressure on the cord has increased with the advance of the disease and then remained for a long time undiminished. For some time after general vitality has been restored the tissues in the infected area are still giving ground! *There is a lag in the arrest of erosion and even after this another lag in the subsequent diminution of pressure.*

The authors agree with Butler in believing that many irrecoverable paraplegias are established because disease persists and toxic vascular or mechanical effects upon the cord become profound and irreparable

Indications for operation

1 *From the neurological point of view* paraplegia
(a) arising in a case of spinal caries which is being efficiently treated or
(b) increasing or unimproved in spite of efficient treatment or
(c) already severe

2 *From the radiological standpoint* paraplegia associated with X ray evidence (or suggestion) of compression
(a) by a tense paravertebral abscess and
(b) by a bony angle or ridge or sequestrum or by posterior disease

In some patients the recognition of posterior osseous disease invisible in

radiographs will depend on the recognition clinically that the sensory tracts are the most severely affected

Finally there are the few patients who have been completely paralysed by Pott s paraplegia and who have for some unhappy reason been allowed to remain completely paralysed for many months The authors feel strongly that they ought to be given the chance of recovery however slight offered by a very careful and adequate decompression under conditions of uninterrupted immobilization The prognosis may be gloomy and the hope forlorn but at the worst the patient will have the satisfaction of knowing that no stone has been left unturned Case H B p 107 is an outstanding example of the value of giving weight to the patient s personal point of view

The conservative treatment of Pott s paraplegia demands a staff skilled in the orthopaedic splintage and nursing of the primary disease and in neuro logical investigation

The surgery of paraplegia demands a skill and experience in spinal surgery with a highly trained team and a well-equipped theatre served by a staff whose aseptic technique is beyond question Indeed the decision between the continuance of conservative treatment or operation demands much experi ence knowledge and wisdom and the choice can only and rightly be free if the surgeon has full and true confidence in his operative skill and judgement in his team and his equipment

Operations

A primary necessity is to establish a sound technique for the maintenance of uninterrupted immobilization during any operation for Pott s paraplegia For more than twenty years one of the authors has employed a technique of splintage in which by the use of a turning-case (see p 154) the spine is fully protected from any movement before during and after the operation. The patient is anaesthetized on his frame or in the cases of sharp angular kyphos on his plaster bed his turning-case is then put on strapped into place and the patient turned (Figs. 91 *a* and *b*) The anaesthetist arranges the flannel bandages between the anaesthetic bars so as to support the patient s forehead When the turning-case is first laid in place but before the patient is turned it is very important for the anaesthetist to make sure that the edge of the turning-case cannot press on the patient s neck or axilla

Warmth In this operation as in others in which a good deal of the body is covered only with sterile towels the patient is kept warm by means of thickly padded sterile towels which have been previously heated.

1 **Costotransversectomy**[1] This is the operation most often indicated and most likely to be helpful Its indication is a paravertebral abscess which

[1] Aspiration of a paravertebral abscess has been recommended (Calot) but the authors feel that it is far better to do a costotransversectomy partly on account of the difficulties and dangers of the aspiration, but mainly because the experience of a considerable number of costotransversectomies convinces them that the abscess contents are seldom thick enough to flow through a cannula

appears tense from its spherical or fusiform shape Asymmetry does not mean lack of pressure One side will often appear the larger and naturally this is an indication for carrying out the costotransversectomy on the side of the large bulge

The side with the greater abscess shadow is chosen An incision 3 inches long is made on the line of the rib with its spinal articulation at the level of the greatest breadth of the shadow The centre of the incision is at the outer edge of the erector spinae The muscles are split and retracted and the dissection is carried to and through the periosteum along the middle of the back of the rib The periosteum is then very carefully and gently raised off the posterior surface the upper and lower edges and finally off the anterior surface of the rib At this point it is wise to insert a long gauze swab between the rib and the periosteum The rib is then divided about 2 inches from the tip of the transverse process The value of the gauze swab is now apparent as it prevents the sharp often needle-like projections on the cut rib ends from penetrating the pleura At this point therefore it is well to bevel off the end of the peripheral portion of the rib smoothly and carefully The inner segment is now grasped by lion forceps and the periosteum and soft tissues separated from it by a blunt dissector the final separation may require a knife on account of its ligamentous attachments or the carefully controlled use of a ¼ inch gouge (It is not always necessary to divide the transverse process) The abscess can now be opened by blunt dissection which should be kept close to the vertebral body The opening should be wide enough to enable adequate exploration of the cavity and the removal of all debris and any sequestra.

Ligation or division of the neurovascular bundle has never been found necessary by the authors After a thorough evacuation the authors sometimes close the wound completely and in others particularly if the pressure has been severe, they leave a rubber drain or a soft paraffin gauze wick in for twenty four or forty-eight hours to avoid any possible secondary pressure After treatment the skin is painted with the special paint (p 40) and if a sinus forms the aseptic and antiseptic technique is carried out on the scrupulous lines there described

2 Laminectomy For decompression in early paraplegia in the absence of radiological indication of pressure from a paravertebral abscess or if indications persist after the evacuation of its contents by costotransversectomy The operation is described with spinal fusion below

3 Posterior spinal fusion *Indicated in Pott s paraplegia after the relief of pressure*

(a) To restore stability in the spine and to provide strong permanent immobilization of the whole of the diseased segment

(b) Especially in mid and low dorsal disease in order to stop the grinding effect of respiration with the result of daily addition to the debris of the abscess

Now and then perhaps laminectomy may be combined with a grafting operation but only in cases where the general condition of the patient warrants the dual procedure Otherwise grafting is carried out at a subsequent session In certain cases of Pott s disease e.g following the recovery of paraplegia under general treatment where the necessity for a subsequent laminectomy may arise a unilateral (right) posterior spinal fusion may be done for this provides stability without interfering with subsequent access to the spinal cord by hemi laminectomy if necessary

Laminectomy and posterior spinal fusion

The exact identification of the spines to be attacked will have been assured by previous localizing lateral radiographs The incision is slightly to the left side so as to keep the scar away from the spinous processes and to allow of the motor-saw being used unhampered by retractors on the surgeon s side The skin and subcutaneous tissue are lifted from the deep fascia and reflected away from the surgeon beyond the line of spinous processes and the skin edges are then closely and smoothly covered with thin green towels

An incision is next made on to the apex of each spinous process and carried by a dip of the point of the knife through the interspinous ligaments over an area covering generally the three spinous processes of the laminectomy area with in addition two above and two below Since the line of processes is often disordered by caries and since it is best to make the incision run exactly over the apex of each process it is helpful to define each process as the incision reaches it by gripping it between the points of a pair of toothed dissecting forceps held in the left hand The motor-saw is then taken and two incisions are made into each spinous process forwards and slightly outwards to right and to left These saw-cuts are clearly shown in Fig 101 *a* They start in the knife-cut and separate a thick flake of bone from the spinous process on each side When each process has been dealt with in this way the saw is laid aside and a chisel the same width as the laminae is used to complete the separation of the lateral flakes of bone from the central part of each spinous process and then to carry these flakes outwards the chisel travelling subperiosteally across the laminae The authors use a broad chisel so that it cannot easily slip between the laminae and so sharp that it can be used gently without dis turbing the diseased spine Each time the chisel travels outwards the space between it and the spinous process is packed with gauze so that by the time the upper end is reached there is a thick packing all the way up that side The other side is then treated in the same way (Fig 101 *b*) The laminae are only *fully* exposed where they are to be removed In the case of the two spines above and below the displacement of the flake of bone and periosteum does not go far beyond the base of the spinous process

The central two or three spinous processes are then removed preferably by giant nibbling forceps and in this step and all others the bone is cut clean by power without suspicion of wrench or leverage which might disturb the area of disease By further gradual nibbling the two or three laminae are removed

cleanly and fairly widely but the preservation of the stability given by t lateral articulations is most desirable It is all to the good if their expos can be made to bring about their fusion.

Further procedure will depend upon the cause of pressure as previou discovered by X rays or found at operation In Pott s paraplegia the sou of pressure is extrathecal and it is ordinarily useless and in the presence infected pus or debris dangerous to open the theca

It is essential to make the laminectomy opening wide and long enough relieve all the pressure present or at all likely to occur Case O.M is an stance of a laminectomy opening which was not long enough though now t

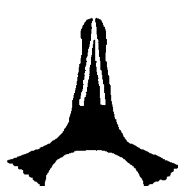


FIG. 101 a. Showing motor saw cuts into a spinous process.

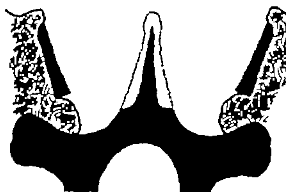


FIG 101 b. State of affairs after reflection of osteo-periosteal flaps in the area of the laminectomy

authors recognize that costotransversectomy would have cured the parapleg as quickly more certainly and more safely than laminectomy! But in this in stance the pressure was great and had been increasing rapidly and it is ther fore likely that either a temporary tuberculous sinus would have formed o else the costotransversectomy would have had to be repeated

It is seldom if ever necessary to remove more than three or perhaps fou laminae for Pott s paraplegia nor to open the dura but rather to seek gentl round it to identify the source of pressure and deal with it Sometimes a ma of caseous or carious debris from the side or the front of the theca is evacuate with a small spoon

The length and shape of the grafts required are recorded by bending probe and two Albee grafts about ½ inch wide are cut from the tibia I straight grafts will fit they are put in with the periosteal surface deep—tha is with the smooth limiting membrane turned towards the theca If the spin is straight or only moderately kyphotic this gives plenty of clearance at th site of the lesion because the grafts are carried fairly high up on the spinou processes above and below If, on the other hand there is much angula curvature one of two methods must be used

(a) *Shaped grafts* to fit the angulation. This means using the broadest par of the tibia and not sparing the crest

(b) *Flexible grafts* (when a graft of sufficient length and angulation is un obtainable) prepared either by the earlier method of multiple transverse cuts about 1/8 inch apart on the medullary side of an Albee graft (and for this a very fast running saw is advisable) or by a technique in which one makes a number of parallel longitudinal cuts into the tibia 1/8 inch apart after a transverse cut beyond each end five or six thin and fairly flexible Albee grafts can be lifted from the tibia Three of these are used on each side like laminated springs

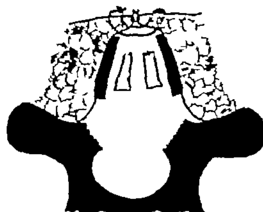


FIG. 102. Showing grafts bridging defect left by laminectomy with their lateral osteogenetic hosts.

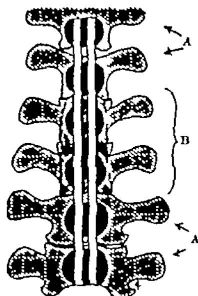


FIG 103. Diagrammatic coronal section of spinous processes and graft with vertebrae and area of laminectomy indicated. *A*. Grafts well supported on spines. *B* Area of laminectomy

flexed to fit the angulation and firmly held to the spinous processes above and below by suturing It is best to use a number of completely separate leaves

When the grafts are firmly in place and one has made sure that there is plenty of space between their deep surface and the theca the edges of the supraspinous ligament are sewn together over the grafts (Fig 102) the lateral flakes of bone from each spinous process are thus brought into contact with the grafts Just previous to this if there are one or more prominent spinous processes they are nipped across with bone-cutting forceps and bent under the suture line This procedure makes for comfort and safeguards the skin from pressure The operation is completed by suture of the skin of the back and the leg Dressings and carefully graded layers of wool are then applied the frame or plaster bed is laid in position the straps are pulled up and the patient is re-turned

After-treatment

The patient remains on his frame or plaster bed for three or four months He is turned whenever necessary by the method described (the routine in *all* cases of spinal caries) and each time the utmost care must be devoted to the exact adjustment and soft smooth padding of spinal frame or plaster bed.

Finally the authors would emphasize three things

1 That if laminectomy is to be employed for Pott s paraplegia it should be supplemented by grafting at the same or a subsequent session.
2 Good technique in such grafting is vital, for the grafts have to bridge the laminectomy opening without absorption Therefore the grafts must be strong and be given as much contact with bone as possible or there will *be risk of their absorption or fracture. It is for this purpose that the* authors separate from each spinous process lateral flakes of bone with their periosteum intact At the end of the operation these lie with their raw surfaces in contact with the grafts providing an almost continuous series of ossific nodes
3 The continuous immobilization of the whole spine before during and after operation.

4. Lateral rhachotomy

To costotransversectomy and laminectomy there has now been added (Capener 193?) a *lateral approach This was designed for access to the* structures lying in front of the theca in a case of late paraplegia with severe angulation

Alexander and Dott in Edinburgh have developed independently a rather similar antero-lateral approach Alexander emphasizes the advantage of the exposure and complete evacuation of the paravertebral abscess after costotransversectomy on the way in, and his approach is rather more anterior than that of Capener Both take away the pedicles Alexander after a radical costotransversectomy Capener keeping rather farther back and doing a partial hemi laminectomy It is probable that these two surgeons have developed *their lateral approach with rather different aims Alexander uses his approach* at any stage early or late whereas Capener developed his operation particularly for late paraplegia with severe angulation If lateral rhachotomy is to be applied to active phase paraplegia we would agree with Alexander that it is wise to include thorough evacuation of any paravertebral abscess there may be However it is uncertain whether any general application of lateral rhachotomy to active phase paraplegia is wise at present It should be noted *that Alexander goes out of his way to maintain immobilization during* and after operation by skeletal skull traction in cervical and upper thoracic disease It should also be remembered that this operation is much less difficult and dangerous when there is a considerable kyphos Where there is little or none it may demand their utmost skill and delicacy from the most able and experienced spinal surgeons

THE END RESULTS AND THEIR LESSON

The disastrous results of operation in Pott's paraplegia without uninterrupted and accurate immobilization have brought about a conservative trend of opinion which was thoroughly justified in the past but is no longer justified. The result of this conservatism has been that many patients *recover from tuberculosis but not from paraplegia*; a larger number die paralysed, their death due more to the paraplegia than to the tuberculosis. In some of the cases in Group A there is delayed arrest of the disease. It is indeed a universal experience in regard to tuberculosis in all parts of the body that a local focus may show persistent activity and increasing destruction of bone for some months after the institution of good general and local treatment. Far more unfavourable are those few patients who fail altogether to respond to treatment; they go downhill until they die. And there are cases in which paraplegia adds to the severity of the illness with painful oft repeated flexor spasms making rest impossible and pressure sores adding septic absorption to the general illness. Butler gives the mortality of Group A as something like 30 per cent in his personal experience and says of this fraction that about one-third die from general spread of tuberculosis. In some of his cases the tuberculosis was complicated by septic absorption from sores and the two diseases combined to kill the patient.

Early expert treatment can minimize this loss.

Paraplegia may persist solely because *operative relief of the cord from pressure is given too late or not at all*.

The group of patients who respond slowly and in whom for months the pressure on the cord may be increasing rather than diminishing, presents to the authors a very strong argument in favour of relatively early relief of the cord from pressure (generally by costotransversectomy). For in such cases the compression is generally due to the gradual accumulation under tension of the products of chronic inflammation and erosion. Relief from this compression can come in two ways: quickly by operation or very, very slowly and after long delay as a result of first the arrest of inflammation and erosion and then the slow inspissation of the abscess. When first-class surgical skill backed by orthopaedic technique and equipment are available there should be no further hesitation. But the combination is essential. Operation, however skilful, without associated splintage based upon experience of spinal caries and its immobilization is futile and the dangers associated with unskilful operation may well be greater than those of leaving the spinal cord compressed *sine die*. In a word, the treatment of Pott's paraplegia demands first-class orthopaedic surgery.

The end results of operations for bone and joint tuberculosis done not as an incident in a long programme of conservative treatment but without regard to immobilization and after-care are bad and of all such operations laminectomy for paraplegia is the most disastrous. The stability of the spine at the site of the lesion is precarious and anaesthesia abolishes the protection of the

After-treatment

The patient remains on his frame or plaster bed for three or four months He is turned whenever necessary by the method described (the routine in *all* cases of spinal caries) and each time the utmost care must be devoted to the exact adjustment and soft smooth padding of spinal frame or plaster bed

Finally the authors would emphasize three things

1 That if laminectomy is to be employed for Pott s paraplegia it should be *supplemented by grafting at the same or a subsequent session*
2 Good technique in such grafting is vital for the grafts have to bridge the laminectomy opening without absorption. Therefore the grafts must be strong and be given as much contact with bone as possible or there will be risk of their absorption or fracture It is for this purpose that the authors separate from each spinous process lateral flakes of bone with their periosteum intact At the end of the operation these lie with their raw surfaces in contact with the grafts providing an almost continuous series of ossific nodes.
3 The continuous immobilization of the whole spine before during and after operation.

4 Lateral rhachotomy

To costotransversectomy and laminectomy there has now been added (Capener 1935) a lateral approach This was designed for access to the structures lying in front of the theca in a case of late paraplegia with severe angulation

Alexander and Dott in Edinburgh have developed independently a rather similar antero-lateral approach. Alexander emphasizes the advantage of the exposure and complete evacuation of the paravertebral abscess after costotransversectomy on the way in and his approach is rather more anterior than that of Capener Both take away the pedicles Alexander after a radical costo-*transversectomy* Capener *keeping rather* farther back and doing a partial hemi laminectomy It is probable that these two surgeons have developed their lateral approach with rather different aims Alexander uses his approach at any stage early or late whereas Capener developed his operation particularly for late paraplegia with *severe angulation* *If lateral rhachotomy is* to be applied to active phase paraplegia we would agree with Alexander that it is wise to include thorough evacuation of any paravertebral abscess there may be However it is uncertain whether any general application of lateral rhachotomy to active-phase paraplegia is wise at present. *It should be noted* that Alexander goes out of his way to maintain immobilization during and after operation by skeletal skull traction in cervical and upper thoracic disease It should also be remembered that this operation is much less difficult and dangerous when there is a considerable kyphos Where there is little or none it may demand their utmost skill and delicacy from the most able and experienced spinal surgeons

THE END RESULTS AND THEIR LESSON

The disastrous results of operation in Pott s paraplegia without uninterrupted and accurate immobilization have brought about a conservative trend of opinion which was thoroughly justified in the past but is no longer justified The result of this conservatism has been that many patients *recover from tuberculosis but not from paraplegia* a larger number die paralysed their death due more to the paraplegia than to the tuberculosis In some of the cases in Group A there is delayed arrest of the disease It is indeed a universal experience in regard to tuberculosis in all parts of the body that a local focus may show persistent activity and increasing destruction of bone for some months after the institution of good general and local treatment Far more unfavourable are those few patients who fall altogether to respond to treatment they go downhill until they die And there are cases in which paraplegia adds to the severity of the illness with painful oft repeated flexor spasms making rest impossible and pressure sores adding septic absorption to the general illness Butler gives the mortality of Group A as something like 30 per cent in his personal experience and says of this fraction that about one-third die from general spread of tuberculosis In some of his cases the tuberculosis was complicated by septic absorption from sores and the two diseases combined to kill the patient

Early expert treatment can minimize this loss

Paraplegia may persist solely because *operative relief of the cord from pressure is given too late or not at all*

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voluntary muscles thus there is danger of crushing the diseased bone or of subluxation. These dangers are present during operation be it costotransversectomy or laminectomy Furthermore after laminectomy the stability of the spine is even further reduced. Only continuous expert immobilization can eliminate these risks. Seddon has done great service in emphasizing the value of conservative measures in paraplegia in collecting his cases he cast his net wide and was very deeply shocked by the results of laminectomy done for Pott's paraplegia with interruption of immobilization or worse without *immobilization* *His* references *to* surgical measures are therefore coloured by his disgust at the results of indiscriminate operating but he disparages operations unduly when he might more helpfully have distinguished good surgery from bad It is indeed true that laminectomy as an isolated procedure for Pott's paraplegia cannot be too severely condemned But decompression of the cord by a carefully selected operation can be a procedure of *the utmost value provided that it is carried out in association with* accurate and uninterrupted immobilization of the spine before during and for months after the operation

We would repeat that the first essential step in the treatment of Pott's paraplegia is the prompt transference of the patient to a first-class orthopaedic centre where there is every facility for open-air treatment for orthopaedic care and for operation under the best circumstances by a surgeon skilled and experienced in spinal tuberculosis

In most of the minor and some of the moderate cases conservative treatment suffices for the paraplegia after a short time progressively fades away But in a moderate degree of paraplegia which does not begin to show progressive signs of amelioration within a few weeks decompression is indicated Costotransversectomy and laminectomy without facetectomy are operations of relative safety Costotransversectomy with thorough evacuation of a paravertebral abscess may have to be repeated or followed by laminectomy through another route if there is no amelioration within three or four weeks. First-class radiography sometimes with tomography facilitates the choice.

Lateral rhachotomy is most valuable when decompression is indicated in early (or late) paraplegia after posterior spinal graft fusion For then approach *to the theca through laminae* immensely thickened into one continuous mass is exceedingly dangerous to the cord and lateral rhachotomy is much safer furthermore the stability is assured by the posterior spinal fusion which the operation leaves undisturbed

In *late paraplegia* lateral rhachotomy has many virtues and almost all where there is extreme angulation *Though the operation is extensive* delicate and cannot be hurried the patient is no longer ill with an invasive and destructive disease and therefore no longer an unfavourable subject for such an operation. Furthermore in most cases stability is assured and the series of lateral articulations on one side can therefore be interrupted without fear

In true cases of late-onset paraplegia unaccompanied by any local re-

presence of disease such as occasionally account for cases in this group paraplegia is associated with prolonged stretching combined with move over a sharp angle or ridge It is true that lateral rhachotomy can provide s for the relatively extensive procedure necessary to give the cord a other and shorter path Yet even when it has been done with the utmost ncy without damage to the pleura or to the vascular supply of the cord result may be utterly disappointing because irreversible degenerative nges already exist

o we are brought back to the conviction that the early diagnosis of spinal rculosis and its prompt effective and complete treatment are the only ns of preventing extensive destruction and severe angulation leading haps to irreparable paraplegia

C.M

ale aged 19 Admitted to the Wingfield Morris Orthopaedic Hospital, 12 January

story For an indefinite period complained of onset of loss of power in both legs mencing three weeks before admission. Patient walked up to Out Patient Depart t with spastic gait Stated that he had had round back.

ray (1*.i.21) Bodies of D 6, 7 and 8 largely destroyed. Abscess shadow Voluntary er—R and L legs nil Spasms—R. and L legs ++ Sensation—light touch lost w 8th dorsal. Sphincters not affected Reflexes—abdominals minus; knee jerks + ankle jerks +++ Wassermann—negative

espite immobilization on spinal frame the paralysis deepened, and became complete or sensory and sphincter

8.i.21 *Laminectomy and graft* D 6, 7 and 8 spines and laminae removed Dura hed through opening at once and began to pulsate well. Prominence palpable in it of cord. This had clearly compressed the cord against the laminae Tibial graft d to bridge the gap from two spines above to two spines below Many transverse s to make it fit.

ensation and muscular control of the lower limbs recovered the same evening but improvement was not maintained and in two or three weeks there was complete sory and motor paralysis and incontinence This persists.

2.vi.21 *Enlargement downwards of laminectomy opening* without damage to graft ft and membranes inspected The theca was found projecting backwards through the inectomy opening and pushed against the lamina at the lower edge of this opening ing to increased accumulation in front of the theca. It was noteworthy that the graft s rounded, covered with a vascular fibrous membrane and had retained its arch; it eared to form an extremely strong and fully adequate internal splint It was found sible to remove enough of this lamina by undercutting the graft

14 vii.21 Incontinence of urine and faeces ceased 30.xii.21 Complete recovery of sation and sphincter control partial control of voluntary power 1*.xii.22. Getting in spinal support and calipers and learning to walk. 21.iii.23 Great improvement in lking 30.iv.23. Discharged 3.iii.26 Very well indeed.

3 xi.37 This patient is now perfectly well and active There is no trace of paraplegia t He has been at work for more than 20 years.

se H.L.

Male aged 21 Sudden collapse of vertebral body while patient was putting on boots, sing complete flaccid paralysis below lesion (see Fig 104, p. 196)

x.33 Laminectomy within a fortnight Laminae of D 10, 11 and 12 removed. No

pulsation of cord below level of D 11 Definite flattening of cord and dura at the upper level of D 11 Cord below this seemed shrunken After full exposure cord and dura swelled out to normal size, but pulsation appeared less in scope There appeared to be a smooth rounded prominence in the region of D 11 that was pushing the cord forwards, but no granulation tissue was found The laminectomy opening was everywhere made



Fig 104 H.L. Male aged 1

smooth A double graft cut from the L. tibia was placed bridging the opening from the 3 dorsal vertebrae above to the lumbar vertebrae below

iv 24 Nephrectomy R (after 5 months haematuria and recurrent high temperature). Stone removed with part of ureter

v.24 Passed a stone X ray—no further stone visible.

xi.24 Massage and gentle movements to legs—improving Still incontinent. Urine: occasional trace albumin. i.25. Spinal support applied

iii.25. Muscular control and sensation returning Some pyuria.

iv.25. *L leg* Voluntary control greatly improved Goes into spasm after a few

minutes effort Sensation slowly improving Can t ll when he is being touched but there is no tactile localization below knee Cannot distinguish between pin and finger

R leg Control not so good as L. Cannot maintain extension of R knee Goes into spasm with very slight provocation. Sensation similar to L. Can distinguish hot and cold fairly well

vi.25. Control of legs improving Still completely incontinent Occasional albuminuria.

vi.25 X ray shows graft intact. vii.25. Stood for a few minutes. viii 25 Walks with one stick and one person helping Still has albuminuria. Temperature normal ix 20 Progress satisfactory less ataxic Urine clear

vi.20. Marked improvement in walking Persevering with exercises and re-education.

viii 20. General condition good Discharged from W.M O H

xii.27 Graft perfect No kyphos. Paresis below D 7 nerve distribution Incontinence of urine and faeces. Legs spastic Plantar reflex extensor

ii.30 Seen at his own home States that he is not entirely incontinent now Walks with a rather spastic and incoordinate gait Voluntary power fair Ankle clonus R and L. Patella clonus R and L. Tight spasmodic T.A R and L. Knee-jerks plus R. and L. Plantar reflex extensor Abdominal reflexes present Sensation to pin prick diminished below line of anterior superior spines.

ix.30 Patient writes: My general health remains very good, but I am unable to get about very much. Activity is confined to operating my Experimental Transmitting Station, no other work of any kind

Case H.B

Admitted Wingfield Morris Orthopaedic Hospital 1.iii.25.

A woman with three years history of Pott s paraplegia with motor sensory and sphincter loss. All signs of tuberculous activity over Paraplegia in flexion with severe flexion deformities of the hips and knees. Knee and ankle clonus. Plantar reflexes; extensors, extreme spastic rigidity

She had been admitted to a special surgical and tuberculosis hospital with complete paraplegia and being discharged 9 months later returned home to the Isle of Wight with a note saying condition of patient unaltered, complete paraplegia and incontinence

Seen again by a surgeon in ix.24 who reported gone beyond repair

Patient s state young married woman requiring constant skilled nursing and unable to return to husband and no hope of ever doing so.

It was explained to the patient that so far as was known there was no hope of recovery and no hope of helping bar operation This caused her the greatest distress for the reasons mentioned She was anxious that if there was the least possibility of hope operation should be carried out however slight the hope

It was decided that her attitude was reasonable and that an operation, which would otherwise have been unjustifiable was justified.

15.iii.25 Operation: laminectomy Four laminae removed The theca was lying in a narrow rather tortuous bed apparently surrounded by firm old granulation tissue which bulged backward into the wound The opening was carefully bevelled and smoothed. Within a month sensation had improved

25.iv.25 Patient still has incontinence of bowel and bladder but now is conscious of desire to go to stool and urinate which she did not have before Sensation has shown a phenomenal return being present equally over the whole body except the dorsum and soles of feet which are slightly hypersensitive to pin prick.

Spasms not nearly so marked Previously patient went into spasm when touched Now has very few spasms. Reflexes not as active Adduction spasm has become much less. Patient can now adduct and abduct knees slightly herself

13 v.25 Patient can move left foot in all directions. No movement in right ankle but can move toes of right foot.



Fig. 103 a



Fig. 103 b

Figs. 103 a and b Case H.B. Woman aged 22. After operation.

16.x.35 Can move hips slightly

13.xi.35 Has about 5–10° range of movement in both knees. Hypersensitiveness to pin prick over plantar surfaces of feet not as marked as before. Reflexes all less active

5.vii.35 Double hip spica applied. 23.vii.35 Plaster wedged at knees. 30.vii.35 Re-wedged. 13.viii.35 Plaster re-wedged at knees.

18.xi.35 Operation. Open tenotomy of hip flexors left. Incision made along the anterior border of the ilium extending down the thigh. All tight structures including the iliopsoas were cut. Thigh then extended as far as possible. Patient has a fixed lumbar lordosis. Put in plaster with left leg extended as far as possible and right flexed on the pelvis.

19.i.36. Plaster bivalved. 30.i.36. To go into the warm swimming bath for exercises.

28.ii.36 Operation. Right knee manipulated into extension. Guarding plaster then applied from groin to ankle with knee almost straight.

19.iii.36. Plaster wedged in further extension. 31.iii.36. Out of plaster. 6.v.36. Walking with caliper. 20.v.36. Walking well.

24.vi.36. Discharged from Wingfield Morris Orthopaedic Hospital.

Feb. 37 Readmitted.

15.ii.37 Operation. Elongation of Tendo Achillis R. and L. R. T.A. lengthened by open operation ½ inch. L. T.A. lengthened by ¾ inch. Operation on R. big toe. Arthrodesis of interphalangeal joint and lengthening of E.P.H. Plaster applied to both feet

8.iv.3[illegible] Re-admitted to W.M.O.H. for review. No spasm of R. leg muscles. No sphincter disturbance. Knee jerks R. and L. = ++. No ankle clonus. Plantar reflexes extensor. Discrimination of fine touch present on trunk and both legs. Hypersensitive on soles of both feet. Heat sensation present on both legs but rather improved on lateral aspect of R. thigh

Needless to say, the patient is delighted to be restored to reasonable activity and to live at home with her husband

CHAPTER IX

THE KNEE

TUBERCULOSIS of the knee is always secondary to active tuberculous else-where, and almost always arises from long-established infection of th lymphatic glands and though this primary lesion may have been presen for a long time, the occurrence of the metastatic focus in the knee is proo that it is active and that from it tubercle bacilli are reaching the blood *Tuberculosis of the knee is seldom fatal, rather is it evidence of an infectio which is often fatal* and operative treatment of the knee, however necessary and however successful, is applied to the flower and not to the root of thi infection. Yet, with the flower gone, it is easy to forget the root, for wit the removal of the focus in the knee goes the only obvious reason for the pro longed general treatment, yet this alone will keep the patient safe until h has killed or imprisoned all the tubercle bacilli in his body

This point has been stressed here once again because the knee is excise oftener and earlier than any other joint Early excision of his knee withou adequate after-care of his whole person is futile surgery, and a very poo service to the patient

PATHOLOGY

Site of infection

There is little or nothing to be added to the general grouping describe above (p 11) The disease may develop and behave as one of synovial infec tion, or on the other hand, it may be clear from X ray evidence that th joint has been infected through visible osseous foci

Synovial arthritis

That the infection of a knee by tuberculosis may be synovial *alone ha* been demonstrated many times at operation For the surgeon, while excising a knee and aiming at a total synovectomy inspects completely the articula *surfaces of femur and tibia*

When preparing a paper on tuberculosis of the knee for the Associatior of Surgeons in 1932[1] one of the authors asked some of the most eminent authorities throughout the world a number of questions His first was Are there any data or conclusions as to the occurrence of purely synovial tuber culosis of the knee Its histology and its prognostic significance,'

Now, 38 out of 41 colleagues who answered this question agreed as to the existence of purely synovial infection and most added that *the outlook is relatively favourable* Only 3 out of the 41 said either that synovial tuber culosis always goes on to osseous, or that minute *osseous* foci always exist

[1] The Pathology and Treatment of Tuberculosis of the Knee-joint. *The British Journal of Surgery* 19 193-, no 5.

round the synovial edges The latter point is of no practical importance it suffices us to know that in young children if no bone cavities can be seen throughout a series of radiographs, and if these cases are treated well enough and long enough many will recover with full movement Soutter, of Boston with 9 synovial cases out of 45, reported 3 with full movement, 3 with fair 3 with unsound ankylosis. Fraser reported that of his synovial cases 17 per cent had free movement 56 per cent had limited movement, 21 per cent some form of ankylosis and that 6 per cent subsequently came to excision

TABLE 19

*Children with Non focal * Tuberculosis of the Knee Treated and watched for 5 years or more at the Wingfield Morris Orthopaedic Hospital*

Results	*No of cases (14)*	*Period since set free from all splintage or restraint* (Years)
Full movement	9	2½ 4 6½ ?½ .. 3 3½ 2½ 2½
Good movements (i.e 180 to above right angle)	2	3½ 3½
Under test	1	Free promising but time insufficient
Still under treatment	1	Promising
Excised, sound union	1	

* Without radiographic evidence of osseous foci.

TABLE 20

Details of the 9 Cases with Full Movements shown in Table 19

Age	*Plaster spica*	*Cal per and guarding plaster*	*Cal per only*	*Total period of splintage*	*Period since set free*
(Years)	(Months)	(Months)	(Months)	(Years)	(Years)
1 6	7+5 = 12*	6+36 = 42*	28	6½	?½
2 3	?0	13		½	4
3 11	9	21	18	4	6½
4 1	7	15	7	½	½
5 5	4+10 = 14	5+9 = 14	9	3	2
6 1½	36	4	27	5½	3
9	8+8 = 16*	4+8 = 12*	21	4	3½
8 1	12	9	4	2	¾
9 7	8	?†	?†	?†	2½

* Two periods—second due to signs of commencing reactivity after remitting guarding plaster in each case

† Owing to defective notes these time-periods cannot be ascertained.

N.B. All children with reasonably good homes become out patients during the second period.

6 **Arthritis with osseous foci** (for extra articular foci see p 12)

When a bone focus has opened through the articular cartilage into the knee the best result obtainable is ankylosis Such a conclusion appears almost inevitable in view of the morbid anatomy, for while an endosteal focus can

be encapsuled, it is necessary, in order to make the wall effective that the focus be completely surrounded by healthy granulation tissue Often of course, the joint is entirely destroyed and replaced by infected granuloma. But even in cases with limited foci, which at first sight are far more favourable sound capping of the opening into the joint is seldom possible It is true that if the opening is away from the weight-bearing surface it can be capped by adhesions, but these will limit movement, and the security of the cap is endangered by a sudden wrench

In this type of case fusion alone can give permanent security. The hope of obtaining safe and permanent healing with good mobility has always been forlorn, and the great majority of the author s correspondents agreed that such hopes are futile He put the question Can you give any evidence of the healing of an osseous tuberculous focus, which has opened into the knee with retention of a freely mobile joint ?' Of 40 who answered this question 35 answered definitely 'No', and some added I don t believe it ever occurs Calvé said, I do not know of any case of an osseous focus opening into the joint with restoration of normal mobility The invasion of the joint is always followed by ulceration of cartilage and then by definite loss of articular function

All these considerations lead to the conclusion that a tuberculous knee with bony foci communicating with the joint (see Fig. 107) should be excised, and the arthrodesis should be performed at a time chosen in view of the age and the general and local condition of the patient

DIAGNOSIS

Only prompt, effective, continuous, and prolonged treatment will prevent synovial disease from becoming osseous. Yet the nature of the disease is such that an early certain diagnosis is often impossible, therefore we must put up with a *provisional diagnosis* and act on it as quickly and stringently as if it were final Diagnosis and treatment must for a time run concurrently

Tuberculosis of the knee is characteristically a monarticular arthritis with a very insidious onset. Generally the first thing noticed by the patient or parent is an interference with function rather than pain. Indeed the characteristic initial feature is the limitation of the full range of movement, soon to be followed by a swollen, warm, and somewhat tender and painful joint The enlargement is due more to infiltration than to fluid Inquiry may reveal (1) the likelihood of human infection (2) previous manifestations of tuberculosis (3) some loss of health and vigour (4) a history of an injury to the knee from two or three months before with a normal joint during most of the interval.

But in early cases it is impossible to make a diagnosis in the out patient room We must therefore be content with a provisional diagnosis, for we can not wait for the development of a conclusive clinical or radiographic picture An uncertain diagnosis is no excuse for hesitant treatment. On the contrary provisional diagnosis must be followed immediately by full-dress treatment



Fig 106 a.



Fig 106 b

Figs. 106 a and b Man aged 62 whose knee had remained painful subject to recurrent attacks of heat and swelling for over 30 years. He ultimately broke the femur as shown above. There was resultant exacerbation of disease ending in amputation.

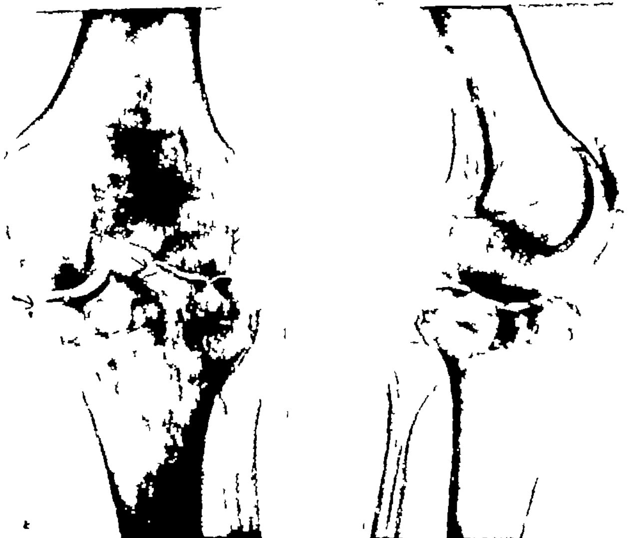


Fig. 107 D.H. Woman aged 29. 4 years history of rheumatism. Knee hot and swollen, with limited and painful movement. X-rays show multiple tuberculous foci in tibia, two or three obviously communicating with joint cavity.

This has been the author's practice for a long time, and its value has been proved for in children under 10 without X ray evidence of osseous foci, early and very long-continued immobilization has led to a complete cure with full movements in the majority of cases There had been a drift toward the feeling they will all come to excision sooner or later We now know that this is untrue—good news which encourages us to feel that our efforts toward the earliest possible provisional diagnosis and prompt admission are fully justified A provisional diagnosis of tuberculosis should be made on what is no more than a suggestive clinical picture whether radiographs reveal pathological changes or not the knee should be immobilized at once and the patient admitted without delay for general treatment and investigation The standard general and local treatment is begun and the confirmation of diagnosis proceeds on the lines already described including biopsy of regional lymph glands

Differential diagnosis

For full discussion the reader is referred to Chapter XI. One or two points specially concerning the knee may be mentioned

Seddon[1] reports that the removal of one or more of the femoral group of inguinal lymph glands has given good results, and it is his opinion that in most cases in which diagnostic operation was indicated this minor operation can replace arthrotomy with advantage

Again, the so-called transient arthritis, which in the hip is transient in name and nature is often far from transient in the knee This may be due to anatomical differences Whereas the hip is a deep-seated, deep-socketed joint protected by large muscular masses, the knee is superficial and particularly exposed to twists and strains and dependent upon muscular protection which is only adequate when at full strength Any form of arthritis is quickly associated with muscular wasting with the result that the joint is at the same time inflamed and insecure over-sensitive, and without its normal muscular protection, a vicious circle which may prolong an arthritis almost indefinitely after its exciting cause has disappeared Curiously enough mere standing about or even sitting with the knee unsupported will worry a knee which has been arthritic and has not yet regained full muscular powers The treatment therefore of an 'observation' knee has to be rather longer and more protective than in the hip, and followed by a rehabilitation of the muscles and joint by graduated exercises.

Then, too, from its exposed position, the knee is peculiarly liable to recurring haemorrhage in haemophilia with subsequent gradual development of a chronic arthritis.

The symmetrical arthritis of congenital syphilis (Clutton's joints) is also to be remembered in that the knees are far more commonly affected than any other joint Furthermore the two sides are by no means always simultaneously affected so that the diagnostic symmetry may not appear

[1] Personal communication.



Fig. 108 a.



Fig. 108 b.

Figs. 108 a and b. Post-traumatic decalcification. Patient aged 45. Radiographs eight weeks after severe injury rather suggestive of tuberculosis, but this diagnosis can be excluded by close attention to the history.



Fig 108 c



Fig 108 d

Figs. 108 c and d The same case one year later The texture of the bones is much improved. The clinical picture was at no time suggestive of tuberculosis.



Fig 100 a



Fig 100 b

Figs. 100 a and b. D.M Boy ged 11 Septic rthritis of knee showing early ankylosis.





Fig 110 a

Fig 110 b.

Figs. 110 a and b Same case as Fig 100 3 years later Showing sound ankylosis. (N B. the knee is too straight, the epiphyses are unaffected and will be subject to great strain, there is grave danger of back knee developing)





FIGS. 111 c and d Clinical photographs of same case.



FIG 112. G P Osteoarthritis. Extensive osteoarthritis of the knee with thinning of the articular cartilage and lipping of all three bones with sclerosis.



FIG 113 Rheumatoid arthritis with decalcification almost complete destruction of the articular cartilage and a general hazy outline due to soft tissue thickening

TREATMENT

General

As the patients suffer from tuberculosis of which the knee is only one and the less dangerous lesion they all need general treatment by physical rest and metabolic stimulation heliotherapy a well-chosen and varied diet and cheerful environment

In adults this general treatment is preparatory to operation but it is wise to explain to the patient that the operation will not lessen the need for continued general treatment and prolonged after-care Indeed it is very doubtful whether after early middle age the inner and unseen glandular disease ever heals soundly for many an elderly patient is readmitted with some new tuberculous metastasis a year or two after excision or amputation. Clearly these elderly patients need specially favourable home conditions. This often presents a very difficult problem



FIG 114 Plaster spica giving complete immobilization of the knee

Local conservative treatment

The local conservative treatment consists *in keeping the joint comfortably and completely at rest* Any heat or disturbance, notably diathermy or massage, applied to the joint is extremely harmful. The joint should be *completely* immobilized, so long as it is warm and indeed for some months afterwards and the best method for this period is a plaster spica including pelvis and foot (see Fig 114)

Deformity due to soft tissue changes can be corrected gradually by cutting and wedging the plaster Fixed deformity can be left for the time and corrected later when excision is performed

In young children, then some months *after* the knee has become cool a Thomas walking splint with a guarding plaster can be applied, and before long the child allowed up (Fig 115*a*) Later the guarding plaster can be left off but the weight bearing appliance must remain for years (Fig 115*b*) In tuberculosis of the knee permanent and disabling limitation of movement is much more likely to result from setting the knee free too soon than from retaining a weight bearing appliance needlessly long With synovial disease this form of immobilization can be continued for years without leading to fixation whereas too brief immobilization or a break in its continuity is

liable to lead to extension and reactivation of the disease, and thus to destruction of the articular cartilage and the loss of all hope of free mobility In children permanent loss of movement is the result, not of immobilization but of disease A study of several series of radiographs of synovial tuberculous knees has convinced the authors that the articular ends of the femur and



Fig 115 a Weight-bearing caliper and guarding plaster

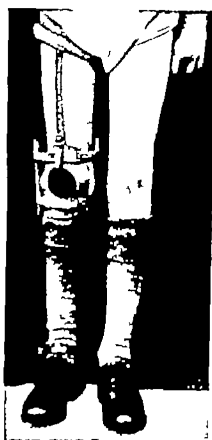


Fig 115 b Weight-bearing caliper

tibia develop almost normally during the years of immobilization and protection from weight bearing Movement returns of itself gradually and progressively if the knee is only set free after the disease is soundly healed.

The gratifying results which are being obtained by conservative treatment in children with synovial tuberculosis of the knee are due to the effective uninterrupted, and long-continued splintage which protects the synovial membrane from movement and the articular cartilage from weight bearing friction

A caliper can only be used with safety if the greatest care is taken to ensure that the caliper is and continually remains, truly weight bearing for the condyles of femur and tibia are porotic and soft and will quickly flatten if

allowed to bear weight (Fig 116) with the result that the movement of the joint is grossly restricted when free movement would otherwise be expected Where the porosis is extreme the Thomas walking splint (Fig 181) is of value for a while as it ensures that no weight will be taken on the affected joint at any time

The most satisfactory appliance is the walking splint designed by Thomas It must be a good fit and comfortable the part of the ring which is in contact with the tuber ischium and therefore takes the weight, must be well padded and flattened so as to be no higher than the point at which the inside bar joins the ring If this is not the case the patient will walk with an ungainly intoeing gait

In children, a knee which has been the subject of synovial tuberculosis should be kept in a weight bearing caliper for a long time, probably at least two years *after all signs and symptoms of activity such as warmth swelling, and tenderness have disappeared* After the first year the limb can be free at night in bed



FIG 116. Flat produced on one femoral condyle as the result of weight bearing in a badly fitting caliper while the bone was still soft. This misfortune resulted in limited movement where a full range would otherwise have been possible.

ADULTS

Operative Treatment

(a) Middle-aged

The primary splintage is a pelvis to foot plaster as in children windowed in front of the knee Excision is carried out when the knee is cool and less swollen and when the patient is on the up-grade For the bearing of other lesions on the indications for excision see p 181

Occasionally however one finds that neither patient nor knee shows any sign of improvement This may be an indication for excision or amputation, if the toxaemia from the knee is the main cause of persistent and increasing illness or it may be just part of a general breakdown of the resistance of the body to tuberculosis In some cases it may be extremely difficult to judge in what proportion the local and the general disease share the responsibility for the failure in recovery and therefore whether radical operation is indicated or not

Extra-articular foci

Now and then it may be possible to eradicate a tuberculous focus close to the knee which has not infected it But it is a very doubtful policy to attempt the eradication of a focus which, though apparently extra-articular, has



Fig 11 Case P P Extra-articula t berculous focus which was successfully excised and resulted in full mobility

already set up irritation of the joint It is the authors opinion that the signs of arthritis associated with an extra-articular bono focus indicate the infection of the joint far more often than its non infective irritation (see p. 13) This if it be true means that there is nothing to be gained by making an attempt to eradicate such a focus by an extra-articular approach and perhaps some risk for if a tuberculous sinus forms and is allowed to become infected pyogenic infection of the joint may supervene In a young child then it is best when an apparently extra-articular focus is associated with

signs and symptoms of arthritis to wait awhile with full local conservative treatment then if it becomes clear that the focus is not in communication with the joint and if interference is indicated it can be curetted by an extra

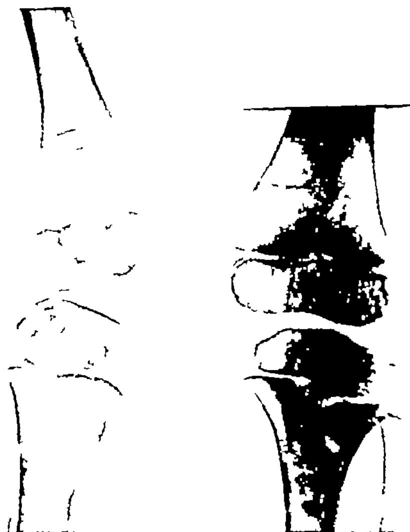


Fig 118. Case D G Large extra articular focus with sinus. Proved tuberculosis. Joint never involved. 7 years later the boy had 90° of flexion.

articular route Perhaps either immobilization or protection from weight-bearing may be advisable for a time the former will be indicated by signs of synovial irritation and the latter by X ray evidence Finally the patient can be set free and put through Thomas's tests

But in a patient over 14 years of age there is no need to wait an operation can be performed If there is no communication well and good but if such a communication is found or if the tuberculous infection of the joint is proved

by the subsequent progress it can be fused before the risk of secondary infection arises

Figs 117 (P.P) and 118 (D G) illustrate two cases of extra-articular foci. In P.P the focus was erased by an extra-articular route In D G an abscess formed it was aspirated and a sinus developed which remained uninfected and healed. P.P has been walking with full free movement since June 1930 and his knee may be regarded as completely cured. The other boy left off his caliper in 1940 and now has a full range of movement

Excision erasion, arthrodesis

There are only two safe end results for a tuberculous knee—free movement or bony ankylosis.

Sound healing with free movement is not obtainable in adults and in children only to be sought when the disease appears to be synovial

In adults then, ankylosis is the aim, this necessitates operative arthrodesis for natural sound ankylosis does not occur and anything short of it is unreliable

In view of these axioms fusion is indicated in all cases of proved tuberculosis of the knee-joint except in children without radiographic foci communicating with the joint and in cases in which it is contra indicated by age or complications

The modern operation whether it is called excision, erasion fusion, or arthrodesis is designed

(*a*) To remove all diseased parts which are accessible without either interfering with growth or lessening the prospect of bony ankylosis

(*b*) To promote bony ankylosis

The dangers of the operation are listed later In the main they are due to operating on cases unduly early unduly young, or with infected sinuses. There is also the danger of forgetting the root because the flower has been cut!

Indications for excision. 1 *After confirmation of diagnosis* by clinical progress a series of radiographs or laboratory tests including in some cases the finding of tubercle bacilli or typical histology in a regional gland or in perisynovial granulomatous tissue

It has already been explained that arthrotomy is only to be done when the knee is ready for excision it can then be the first step of the excision or if microscopic evidence is needed can precede excision by a week or two i e a time too brief for the establishment and possible secondary infection of a tuberculous sinus

2 Excision is the standard practice for patients *aged 15 to 50*

3 *Stage* in treatment when excision is performed

(*a*) In adolescents and adults Only after the general illness and local activity have been checked by general treatment and immobilization

(b) In children with radiographic osseous foci Only when the conservative treatment is complete and the patient is old enough—10, 12 14, 16—opinions differ

(c) In children without radiographic osseous foci Only after radiographs have revealed damage to the articular surfaces and the patient is old enough

Technical points (1) *Tourniquet and towelling* A tourniquet is valuable for the earlier stages of the operation but it should be removed for haemostasis before any sutures grafts pegs or nails are applied The tourniquet makes the operation easier for the surgeon and the patient loses less blood and is less exposed to toxaemia and perhaps bacillaemia The towelling should be well folded and clipped round the limb above and below the knee so that the leg is stockinged and the thigh trousered otherwise gaps appear when the knee is fully flexed during the operation

2 *Division of ligaments* After removal of the suprapatellar pouch the complete division of the medial, lateral, and crucial ligaments facilitates the posterior synovectomy *the posterior capsule is cleaned* and left intact

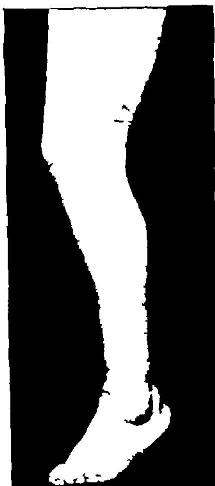


Fig 119 Showing end result of excision. Position of choice for average use

In adults the infected soft tissues should be completely removed both because they are tuberculous and therefore capable of preventing osteogenesis and thus frustrating fusion, and because the disease of the *soft tissues may persist even after successful* arthrodesis. Remember Robert Jones's dictum In adults treat tuberculous tissue as if it were malignant disease ! But in children the operation having been postponed to adolescence generally comes at the end of long conservative treatment all the signs of synovial inflammation have long ago disappeared and there is now no point in formal synovectomy Any thickened *synovial membrane is removed*, the cartilage of the articular surfaces is shaved off, and if any osseous foci are present they are thoroughly scraped out with a sharp spoon But there is no need to level the bone down to the bottom of these excavations, and indeed to do so is thoroughly wasteful and wrong The surfaces are prepared with the general aim of removing the *least amount of bone possible* in order to maintain length

and of bringing into contact large mutually adapted areas of vascular bone in order to promote rapid and strong union

In the authors view the knee should never be straight, they believe that an angle of about 150° is a fair average for an adult The angle is chosen to suit the sex and occupation of the patient Flexion favours sitting, at work, in motor bus train, church, and theatre and with the flexion balanced by a raised heel, the patient can walk almost as well as with a straight leg

Removal of tourniquet. The tourniquet should be removed as soon as the bone surfaces have been prepared and in any case should not be kept on more than thirty minutes. All bleeding points are then tied or fixed

Internal fixation Most surgeons who cut the bone-ends square use some form of internal fixation Favourite methods are decussating bone pegs or long nails which project from the plaster and are removed as soon as the plaster is set or several weeks later Some use the rawed patella this is not recommended because if one removes very little bone it must be used as a free graft and indeed a desire to use it tempts one to remove too much and set the knee too straight Hinged osteoperiosteal flaps from femur tibia or both are mentioned by some writers

But by the ball-and-socket method apposition is easily maintained and slight accidental alteration of the angle of flexion does not interfere with the area of bony contact so that there is little need for internal fixation or grafting

Drainage for twenty four hours is advisable

Compression arthrodesis

Key has recently described a method of arthrodesis with compression of the cut bony surfaces This has been elaborated by Charnely, After the articular surfaces have been denuded and synovectomy if necessary done a Steinmann pin is passed horizontally through the lower end of the femur and another through the upper end of the tibia. These are then clamped together by adjustable turnbuckles to obtain firm apposition The wound is then closed

The advantages of this method are firstly union is more rapid secondly only a Thomas s splint is required post-operatively and thirdly there is a remarkable absence of post-operative pain The compression is retained for from three to five weeks when the pins are removed and a guarding plaster applied until union is complete Figs 120 *a* and *b*

Method of immobilization A plaster spica including pelvis and foot is sometimes used though a few surgeons still prefer the Thomas s bed splint with gutter adaptation splints. Flying buttresses of plaster or ferro-plaster enable one to cut in outline at once a large window removable (and replaceable) for dressing the wound and removing the drains.

Length of immobilization. It is wise to leave the patient in the spica for ten or twelve weeks then use a guarding plaster, with a caliper flexed to fit (Fig 121) until radiographs show sound union



FIG. 1[illegible]0 *a*.



FIG. 1[illegible]0 *b*.

a. Technique of compression arthrodesis (Charnley). The Steinmann pins are drawn together by turnbuckles.

b. After three weeks when the pins are removed.

Great care must be taken to avoid imposing any angular strain upon the union until it is solid Some axial compression is however beneficial, and the calliper need not be weight bearing

Possible sources of failure Fusion is by no means automatic but sound clinical judgement followed by skilful operation and accurate splintage will ensure a very high percentage of success

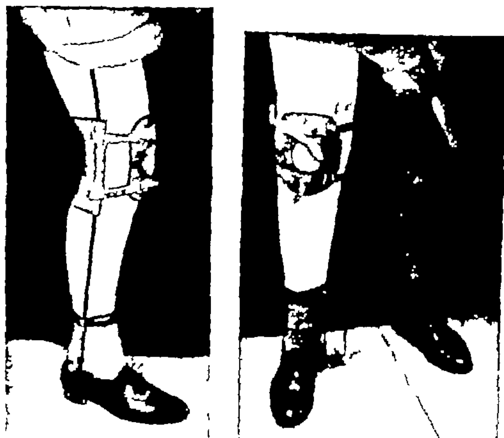


Fig 121 Guarding plaster with calliper flexed to fit.

Failure may be due to

1 Operating while the disease is active, the patient ill and the local resistance so poor that local tuberculous recrudescence takes place

2 Active tuberculosis elsewhere, making the patient too ill to produce union despite the absence of local tuberculous recrudescence (One such case has occurred at the Wingfield Morris Hospital the patient ultimately succumbing to phthisis a year or more after the operation)

3 Pyogenic infection from poor technique or a pre-existing infected sinus. This is a major disaster but the danger of sepsis has been immensely reduced by modern methods of chemotherapy it is therefore no longer necessary to regard an infected sinus as a contra indication of excision

4 Ineffective immobilization allowing displacement during the period be-

tween the end of the operation and the completion of the plaster, or mobility afterwards.

5 Operation done unwisely on a very young patient is almost sure to fail (a) from lack of bony union because the ossific nuclei in the epiphyses are relatively small (b) because secondary deformity develops from the unusual strains thrown on the young, weak bone laid down on the metaphyseal side of the growth disc or (c) from the classic error of the past—namely interference with growth from a too-radical operation resulting in damage to one or both discs The authors had a girl of 20 under their care she was operated on elsewhere while a young child the growth discs were damaged and her leg is 7 inches short.

Contra indications to excision

1 Childhood
2 Persistent illness with fever and toxaemia
3 Active phthisis.
4 Extensive involvement of the femoral shaft
5 Active septic infection of sinuses despite preparatory drainage or free exposure scraping and packing This fifth contra indication may be eliminated by preliminary radical excision and saucerization of the infected sinuses.

The drainage should be thorough and one or other modification of Winnett Orr s technique should be adopted in preference to the use of tubes If skilful and radical measures fail to lead to the healing of the sinuses due probably to inaccessible pockets amputation is in the authors opinion infinitely preferable to excision because more conclusive and far less dangerous in such circumstances.

RESULTS

One of the authors asked his correspondents for their experiences as to the percentage of bony ankylosis after excision Henderson of the Mayo Clinic reported 104 excisions with bony ankylosis in 171 cases (88 per cent) Putti recorded 104 cases with 66 6 per cent of bony ankylosis 26 other correspondents have returned figures (mostly estimated) and these averaged 87 per cent In a series of Wingfield cases done by his colleagues and him self comprising 26 cases with sufficient interval since operation to furnish end results with 88 per cent of sound bony fusion There were 3 failures one was a middle-aged woman ill with a superadded pyogenic infection the second was a middle-aged man with phthisis who died from that condition between one and two years afterwards the third an adolescent whose joint had been very extensively destroyed has a sound fibrous but not bony ankylosis he has been hard at work for more than three years and there is no clinical or radiographic sign of tuberculosis In the remaining 23 cases sound bony ankylosis resulted Of the 3 failures 1 is a relative success and in the other 2 cases the author now knows that excision was contra indicated

The authors do not know of any case in which excision has led to tubercu lous dissemination Doubtless that danger is minimized by the preliminary conservative treatment and the use of a tourniquet at operation

Excision of the knee came out of the inquiry with an excellent reputation. It should, of course, be reserved for cases in which we know from the type of the disease or from the age of the patient or after failure of a prolonged trial of conservative measures that it is futile to hope for movement with sound safe healing But although a soundly ankylosed knee compares poorly with a normal joint it is, *ceteris paribus* much better than an above knee amputation.

Amputation

To the question 'What do you consider the indications in the age groups 0–14 15–50 and 50 upwards *for amputation? Elmslie's answer was* representative Amputation under 14 only when the case does very badly with conservative treatment Young adults only when doing badly under conservative treatment and if the bone disease is too extensive for excision. Older people in any case are unsuitable for excision

One may say that amputation is indicated only when either the patient or the limb has otherwise little prospect of recovery This means that amputation is indicated *rarely* It should be reserved for the patient who is very old or very ill, or for the knee which is very extensively diseased or heavily infected with pyogenic organisms (*see* Table 22)

TABLE 21

Knee Operations

47 cases

Synovectomy + excision—26 cases.
Average age 24 years.
symptom period 2 years (one case 23 years).
Results 21 cases—firm fusion in satisfactory position.
1 case—not firm 0 months after operation (last note).
1 —died of pulmonary tuberculosis 7 months after operation.
3 cases—incomplete
Arthropsy followed by synovectomy + excision—10 cases.
Average age 21 years.
symptom period 3 years.
Results 7 cases—firm fusion in satisfactory position.
2 —unknown.
1 case —incomplete
Synovectomy alone—1 case
Result good mobile joint
Amputation—9 cases
Average age 44 years (excluding the 2 year old child).
symptom period 12 years.
Results 8 adult cases 7 cases satisfactory
1 case—pain, phantom limb type necessitating chordotomy
1 case aged 2 years: satisfactory (amputation done for severe secondary infection).
Anterior wedge osteotomy—1 case for excess flexion.
Result firm fusion in satisfactory position.

TABLE 22

Amputations for Tuberculosis of the Knee Wingfield Morris Orthopaedic Hospital

	Age	Reason	Result
1	–6	Very extensive pyogenic infection of fixed flexed knee	Good for a year or more but subsequently developed lesions in spine and rib; still under treatment.
–	39	Active phthisis.	Good
3.	60	Age Recrudescence of disease after 52 years.	Good, except for pain of phantom limb type
4	57	Age	Good.
5	36	Extensive pyogenic infection	Good.
6.		Active extending secondarily infected disease and general illness threatening lif	Good.
7	44	Active phthisis.	Good.
8	45	Chronic phthisis.	Good
9	30	Long history Severe extensive pyogenic infection.	Good.

Sir Robert Jones has taught us that in a patient past middle age tuberculosis must be dealt with almost as radically as malignant disease In deciding between excision and amputation one takes into account the relative senility of the patient and the extent and activity of the disease There are very few patients whom Osler would have found too old at 40 for excision, and some perhaps who are too young at 60 for amputation. Freiberg conveyed a useful hint when he said We feel that amputations are probably not done often enough in patients beyond middle age But the authors would not be fair to their correspondents if they did not express their abhorrence of avoidable amputation.

Sinus formation

There is a vast difference between a tuberculous sinus and a sinus secondarily infected. A tuberculous sinus will as a rule close quickly if the general and local treatment is good So long as it remains it is a danger because it exposes the knee to the risk of pyogenic infection and this catastrophe can be avoided only by very careful antiseptic dressings (see p 46) A tuberculous sinus should never be probed!

Arthroplasty

To a further question Has arthroplasty any place in the after treatment of tuberculosis of the knee? 32 of the 44 answers were decided negatives Fairbank underlined his No four times and Calvé said *Criminal!* Very convincing too is a plain No from Putti probably the greatest exponent of arthroplasty of the knee

There remained 12 who gave a qualified assent to the idea that an arthroplasty might possibly be warranted under exceptional circumstances—for

example as Willis Campbell pointed out when first one knee has had to be fused and later the other has suffered in the same way Their argument was that the particular circumstances of the case might possibly warrant an arthroplasty of the first knee provided the time interval and radiographic appearances justified it On the other hand Willis Campbell[1] himself in reporting a series of 57 cases of arthroplasty for ankylosis gives an analysis of the origin of the ankylosis and not one was tuberculous. A joint destroyed by very slow and wasting disease offers poor material for arthroplasty A sound ankylosis of the knee in good position is very much better than a poor arthroplasty and for a working man or woman incomparably better

The fibrous ankylosis following conservative treatment is seldom permanently safe from recrudescence and time alone does not bring safety An example of this is furnished by a case of the authors in which tuberculous recrudescence occurred moderately from time to time and finally severely fifty two years after the original attack. Taking everything into consideration it is fair to say that in fibrous ankylosis following tuberculosis arthroplasty is unsafe and after bony fusion definitely undesirable Clearly then there is no justification for arthroplasty in tuberculosis of the knee

SUMMARY

Pathology

Tuberculosis of the knee is a dual disease—an outspoken lesion in the knee arising from another deep unseen, and much more dangerous lesion

Cases can be classified into three groups by the topography of infection and again into three groups by the age of the patient and each group calls for a different line of treatment.

Three groups distinguishable by radiographs

(a) *Extra-articular With osseous foci which appear to be extra-articular* The question of radical elimination of these foci by an extra-articular route is discussed and Calvé s warning considered.

(b) *Osseous With bone foci communicating with the joint* Reasons are given for the decision that the joint should be fused and the arthrodesis performed at a time chosen in view of the age local and general conditions.

(c) *Synovial Without foci that can be seen in radiographs* In such cases in young children there is good hope of recovery with full movement after very long continued immobilization (see *Tables 19* and *20*)

Three groups distinguishable by the age of the patient

(a) *Young children* 0–10 for whom prolonged immobilization is indicated but neither diagnostic operation nor fusion.

[1] Willis Campbell, *Surgery Gynecology and Obst.*, 1923 July 39

(b) *The adolescents and adults* 15–50 for whom immobilization is prepara tory to confirmation of diagnosis by arthrotomy followed by fusion (rarely for particular reason by amputation)
(c) *The elderly* from 50 onwards for many of whom amputation is com monly wiser than fusion

Diagnosis

Provisional diagnosis coupled with immediate treatment is the first step after which for a time treatment and diagnosis run concurrently In young children indeed a *clinical diagnosis* carefully tested and reviewed is suffi cient

Reasons are given for the conclusion that *diagnostic arthrotomy* is contra indicated until the patient reaches an age when a positive diagnosis of tuberculosis will be quickly followed by fusion The difficulties and risks of arthrotomy are discussed and a definition of its indications is suggested

Treatment

General A combination of physical rest and metabolic stimulation serves to restore the vitality of the patient and to raise it to a high level This level should be maintained through the months or years of lymphatic disease and tuberculous bacillaemia. And the care must not be lessened or its period shortened because the knee has been fused.

Local There are only two safe end results in tuberculosis of the knee free movement and bony ankylosis

The aim of local treatment then is the restoration of full movement and, failing that bony ankylosis Immobilization is the paradoxical method of restoring movement

Operative fusion is discussed its rationale its indications, its technical points its contra indications and its failures. Figures are quoted On the whole it is highly successful but should be avoided in those too young too old too ill, or obstinately septic.

Amputation has a restricted field as a life-saving measure for those dis qualified for fusion by illness age or sepsis. Outside this field it is unani mously condemned.

Arthroplasty has no place in the treatment of tuberculosis of the knee or its results for it is almost always either unsafe or impracticable

CHAPTER X

SACRO ILIAC JOINT

TUBERCULOSIS of the sacro-iliac joint may be an isolated lesion affecting one, or rarely both sacro-iliac joints or it may occur as one among several tuberculous lesions in the same patient

In 140 cases recently investigated by Seddon [1] the disease was apparently confined to the sacro-iliac joint in about 50 per cent accompanied by other tuberculous lesions in the remaining 50 per cent In the results published by Seddon and Strange [2] they divided their cases into three groups closed isolated lesions, isolated lesion with sinuses and associated tuberculous lesions

They found that over six years in closed isolated lesions, the mortality rate was only 9 7 per cent where there were sinuses the mortality rate was 24 5 per cent and where an associated tuberculous lesion was present the mortality was 55 2 per cent In determining the prognosis these figures speak for themselves

The disease occurs most commonly in young adult patients. Of 35 Oxford cases there were none in the first decade 9 in the second decade 13 in the third, 9 in the fourth 1 in the fifth and 3 in the sixth

The lesion is usually situated in the subchondral bone of the lower half of the sacro-iliac synchondrosis The upper part of the articulation is seldom affected initially and even in the later stages the disease rarely spreads to this region

As in the case of many other joints the cartilage is undermined and lifted by the formation of tuberculous granulation tissue and thus deprived of its blood-supply is sloughed off into the joint The neighbouring ilium, and to a less degree the sacrum, are liable to infiltration and necrosis, not infrequently with the formation of sequestra of fair size (Figs. 122 a and b) later perhaps progressive bone destruction often results in the formation of an abscess and the pus may track forward under the iliopsoas and point in the groin or backward forming a fluctuating swelling behind the joint Finally if there is no arrest of the disease the joint becomes completely disorganized and the abscesses break down forming sinuses which if secondarily infected, constitute a most intractable form of chronic suppuration and are likely to require most radical drainage.

DIAGNOSIS

The onset and early progress of the disease is often insidious and practically symptomless so that patients may present themselves for examination with abscess formation already present

[1] Personal communication.
[2] Seddon and Strange Sacro-Iliac Tuberculosis British Journal of Surgery 28, p 193, 1940



Fig. 122 a. V.B. Man aged [illegible]4. Tubercular disease of left sacro-iliac joint with sequestra. Abscess left buttock—aspiration impracticable. Pus thick and fibrinous. Operation ix.37—excision of sequestra.
X ray viii.37 shows appearance before operation.



Fig. 122 b. Same case 3 months after operation.

(1) Pain, localized to the affected joint is usually present though often not of great severity and there may be tenderness on palpation of the joint behind But and the point is very noteworthy Kernig's test, and hyper extension, compression or rotational strains applied to the joint are often unprovocative of pain at any stage If an abscess is present which has passed beyond the confines of the joint fluctuation will be detected in the iliac fossa or behind the joint



Fig 123 M.J Some months after operation for secondary infection of left sacro-iliac joint. Showing removal of whole posterior superior spine region of ilium and the back of the sacro-iliac joint. Result—sound healing

Radiographs of this joint should always be stereoscopic They show in the early stages blurring of the outlines of the joint and decalcification of the adjacent bone. In more advanced cases there is radiographic evidence of destruction of bone and sometimes sequestra may be seen (Figs 122 a 124 a and b) The lower part of the joint is more often attacked than the upper and the ilium more often than the sacrum

Provisional diagnosis

As in the hip, patients with early symptoms and signs suggestive of tuberculosis should be admitted, under a provisional diagnosis more especially so if they are ill In disease of this joint the restoration of health of the patient is a matter of greater urgency than the local treatment of the joint, for two reasons first because the prognosis is good if no other lesion or



Fig 124 a E.T Girl aged 20 Tuberculosis of right sacro-iliac joint with sequestration.



Fig 124 b Same case 1 year after double Verrall grafting.

complication exists or arises, secondly because the movement of this joint is always negligible.

Differential diagnosis

(1) **Acute arthritis** The sacro-iliac joint may be *the* seat of acute inflammation due, in most cases to a blood-stream infection by the *Staphylococcus aureus* The disease is characterized by sudden onset, severe pain and tenderness of the affected joint and constitutional disturbance with high fever Suppuration may follow or the inflammation may subside without pus formation. Radiography shows no change in the early stages Later there may be some evidence of local destruction or reaction in one or other neighbouring bone and if the whole joint becomes infected, destruction of the joint surfaces, leading to ankylosis but long before this abscesses will have formed and required incision and a bacteriologist s diagnosis will have been made

2 **Subacute and chronic arthritis (including rheumatoid arthritis)** This condition may closely resemble tuberculosis of the sacro-iliac joint clinically but is more frequently bilateral The usual complaint is of pain localized to one or both sacro-iliac joints. This is of a constant aching character often more severe than in cases of tuberculosis and more easily elicited or exacerbated by the usual test strains applied to the joint The diagnosis can sometimes be made by X rays, which may show some loss of the normal clear joint outlines not necessarily confined to the lower part of the joint, and perhaps a layer of hypercalcification on the sacral or iliac side The condition may be mon-articular or part of a poly articular rheumatoid arthritis and like other joints the condition may be toxaemic or due to a low grade infection which never goes on to suppuration.

3 **Osteoarthritis** This is seldom confined to one sacro-iliac joint being more often part of radiologically obvious lumbar and lumbo-sacral hypertrophic arthritis The X ray signs age incidence and clinical picture distinguish them from tuberculosis

4 **Spondylitis Ankylosa.** The sacro-iliac joints seem to be constantly and early affected in this curious and disabling disease The sacro-iliac disease is much more insidious and less painful than the spinal manifestations *and the sacro-iliac signs and symptoms are overshadowed* by the ankylosing spondylitis which may affect the whole spinal column and major joints especially the hips Radiographic changes in the sacro iliac joints appear early and are always bilateral (Fig 81) They take the form of a mottling of the bones constituting the joint a rapid melting away of the cartilage so that before long the whole joint line has disappeared. The widespread nature of spondylitis ankylosa and its characteristic tendency to cause progressive and rigid ankylosis of the affected joints soon become apparent and there should be no difficulty in differentiating it from sacro-iliac tuberculosis.

5 **New growths** Sarcoma or deposits of secondary carcinoma may affect the lateral mass of the ilium in close relation to the sacro-iliac joint and give rise to symptoms and signs not easily distinguishable from tuberculosis of the joint A soft tumour may simulate an abscess with false fluctuation but so soft a tumour will usually give palpable pulsation and the diagnosis is made clear by the characteristic radiographic appearances (Fig 125)



FIG 125 R.F Man aged 45 Extensive destruction of left sacro-iliac joint by round celled tumour

6 **Sacro iliac strain or subluxation** This common condition may resemble early sacro-iliac tuberculosis There is usually however a history of injury or strain the pain is at times much more severe and more variable and comes on in attacks with relative freedom between them and radiography shows a normal joint It is aggravated by any sort of strain and the pain is of a type different from the deep-seated quietly persistent aching of tuberculosis The great point of distinction however is the sharp pain elicited by straining the sacro-iliac joint. It is impossible to give a more specific account of the group of conditions traumatic anatomical sometimes complicated by toxaemia which are included in the term sacro iliac strain

Operative diagnosis

The authors have no hesitation in recommending arthrotomy whenever real doubt remains after treatment under provisional diagnosis By this time the diagnosis will rest between subacute (? rheumatoid) arthritis and tubercle with perhaps tumour

The lower end of the joint is exposed by a rather miniature posterior Smith Petersen incision In doing this great care is exercised in the introduction of the end of a long strong blunt dissector into the top of the sciatic notch, it must be pushed down along the ilium and round into the notch in close contact with the bone This protects the gluteal arteries. Arthrotomy is completed by removing enough of the posterior part of the iliac contribution to the lower end of the joint

TREATMENT

General

As soon as a provisional diagnosis has been made the patient should be admitted to an orthopaedic hospital without delay Here he is brought under the régime already described in detail elsewhere in this book. If the diagnosis is established the standard general treatment which has already been started, will be continued But operative fusion probably plays a larger part and takes the stage earlier in this joint than any other again for two reasons because there is no question about fusion being the best possible end result and secondly there is no adequate ambulatory external splintage Therefore after a sufficient period of general treatment and local immobilization on a frame or plaster bed some form of operative arthrodesis is carried out The preparatory treatment usually occupies at least three months during this time the patient s general health is restored and his vitality raised as evidenced by the improvement in his appearance and appetite the absence of night sweats and the stabilization of temperature records Conservative treatment will, of course be continued if there are contra indications to fusion

Local

In order to obtain the necessary complete rest both for the patient and his local lesion he is placed as soon after admission as possible on a Jones spinal frame or on a plaster bed. The former is preferable for it allows more complete exposure of the patient s body to the air wind and sky

If a psoas abscess is present it is treated by aspiration, repeated as often as may be necessary If the contents will not pass through a Gauvain cannula the abscess may be opened and thoroughly evacuated by a muscle splitting incision just above Poupart s ligament The wound is sutured and the skin painted with the blue dye (p 45). If the wound breaks down and a sinus forms it will heal as long as secondary pyogenic infection is prevented by careful antiseptic precautions in the dressing of the wound If the abscess is pointing posteriorly it is treated on the same lines the patient being turned periodically by means of the turning case to allow the necessary aspiration *operation or dressing to be carried out*

When the prescribed period of general treatment has elapsed operative synostosis should be performed in almost every case of sacro-iliac tuberculosis The presence of a psoas abscess or uninfected sinus is not a contra indication to operation provided that the patient s condition is satisfactory in every

other way And it is permissible in some cases to do posterior extra articular graft fusion even with an infected anterior sinus A posterior abscess or sinus on the other hand does, in the authors opinion preclude operation unless it can be avoided and in these cases aspiration or surgical drainage must be continued till no fluctuation can be detected or a sinus is healed

Opinions differ as to the best method of fusing a tuberculous sacro iliac joint In America both the Smith Petersen and Campbell types of operation



FIG 1*6. Woman aged 24. Eight months after modified Verrall graft.

are frequently performed. At Berck-sur Mer advantage is taken of the fact that the disease most often involves the lower half of the joint and the upper portion is fused by an intra-articular peg graft or Smith Petersen operation

The authors practice is to fuse the joint by the extra-articular method of Verrall modified by the introduction of a second graft on the affected side only more or less parallel with the first and usually of only half the length passing subperiosteally between the sacral spines and the ilium just below the posterior superior iliac spine

The operation is done with the patient lying prone on the turning case as in the cases of spinal fusion The grafts are introduced by means of three short incisions not by turning down a large flap as in the original Verrall technique A short straight incision is made in the mid line over the upper sacral spines and these are exposed and stripped laterally so as to expose the posterior surface of the sacrum and ensure by direct vision that the grafts pass across at the correct level i.e under the sacral periosteum and through

the bases of the spinous processes Two curved lateral incisions are made in the form of brackets ( ) one on each side, so as to expose the ilium at the level of the posterior superior spine By means of long bladed narrow gouges or chisels the ilium is tunnelled deep to the posterior superior spine and the instrument worked across the posterior surface of the sacrum passing through the bases of the sacral spines and into the opposite ilium This operation is only free from danger if the greatest care is taken in preserving the back of the sacrum The layer of bone protecting the sacral canal is often extremely thin and here traction with damage to the sacral nerves is only too easy The authors feel that whenever grafting whether vertical or in this case transverse is applied to this region, the preparation of the raw bed should be carried out as much as possible *under direct vision*

In the application of the Verrall graft one should aim at applying the endosteal surface of the graft to the prepared raw surface of the sacrum and under the raised and fragmented sacral spines One must always be on the look-out for spina bifida occulta which in the form of posterior sacral defect leaves the cauda equina exposed to damage At the lower level the instrument is passed only just beyond the base of the sacral spine which it penetrates Two fairly stout pointed grafts of the requisite length are then cut from the left tibia and hammered home along the previously prepared tracks.

After operation the patient remains immobilized on his frame or plaster bed for a further period of at least three months Then if the radiographs show satisfactory fusion of the grafts he is taken off his frame allowed a short period of freedom in bed with massage and exercises of the muscles of his limbs and back, fitted with a strong sacro-iliac belt of the Mennell[1] type and gradually allowed up After discharge from hospital the patient is kept under regular observation at a clinic with periodical X ray checking The belt may usually be discarded at the end of a year or two if radiography shows satisfactory fusion and arrest of the disease

In cases where secondary infection of sinuses has occurred resulting in a hectic type of temperature chronic profuse suppuration and loss of weight and deterioration in the patient s general health a very radical drainage operation offers the only chance of preventing amyloid disease with its inevitable ending

The joint is approached by a posterior incision directly over it and a large wedge of iliac bone removed sufficient to allow free access to the joint cavity All pus sequestra caseous matter and necrotic bone and cartilage debris are removed and the walls of the cavity curetted till healthy vascular bone is reached Here as in the hip (pp 108–18) the recesses of the joint should be thoroughly saucerized The cavity is then packed with linen impregnated with soft paraffin which is left in place for the first three or four weeks then changed at infrequent intervals.

[1] Mennell, James, M D *Backache* J and A. Churchill, Gloucester Place, Portman Square 1931

TABLE 23

Non-operative End results

(Length of time since treatment not known)

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Total*
Well and working		1	1	2			4 = 40 per cent
Untraced		1					1 = 10
Incomplete							—
Unsatisfactory				2			2 = 20
Died				1			3 = 30 "
		[illegible]	1	5		2	10 = 100 per cent.

Table 23 shows the results of conservative treatment alone of 10 cases of tuberculosis of the sacro-iliac joint The number of cases in each decade is also indicated

TABLE 24

Operative End results

Types of treatment	*No of cases*	*Results* *Well*	*Died*	*Untraced*	*Incomplete*	*Unsatisfactory*
Double Verrall graft only	20	6		4	10	
Smith Petersen graft only	1				1	
Double Verrall + I.A.A.* + Smith Petersen	1				1	
Smith Petersen + peg graft	2	2				
Smith-Petersen + Double Verrall graft	1				1	

Table 24 shows the various types of operation used in 23 cases of tuberculosis of the sacro-iliac joint and the results obtained

* The intra-articular procedures are infrequently employed and then only in doubtful cases for diagnostic purposes.

I.A.A. = intra-articular arthrodesis.

TABLE 25

Operative End results

Results	*1–10*	*11–20*	*21–30*	*31–40*	*41–50*	*50+*	*Totals*
Well and working		6	6	2			14 = 56 per cent.
Untraced		1	2				3 = 12
Incomplete		3	1	2		1	7 = 28
Unsatisfactory							
Died		1					1 = 4
		11	9	4		1	25 = 100 per cent.

Table 25 shows the results of conservative + operative treatment of 25 cases of tuberculosis of sacro-iliac joints.

CHAPTER XI

ANKLE

TUBERCULOSIS of the ankle is not uncommon. The clinical picture is similar to that of the hip or knee and, as in these joints the condition may be primarily synovial or osseous. Radiographs may reveal an extra-articular focus in the tibia above the epiphyseal or bone foci communicating with the joint plate (Figs. 127 *a* and *b*) or in the astragalus

DIAGNOSIS

This follows exactly the process which has been described in regard to the hip and the knee The provisional diagnosis of observation ankle will again often be found useful and there is nothing additional to be said in regard to differential diagnosis

TREATMENT

General

The treatment is standard

Local

1 Conservative *Prolonged immobilization* The opinion has been expressed that some form of metal splint e g the Thomas claw splint, is preferable to plaster—and even that abscess formation is less likely with this form of splintage The authors much prefer the better and more continuous immobilization afforded by plaster During the conservative treatment of tuberculous arthritis of the joint the caution regarding heat must be remembered and care taken to avoid the plaster being exposed to the sun. Lack of this precaution may well promote reactivity of disease for which the plaster may be unjustly blamed

If there is any suggestion of abscess formation the plaster should be split to allow an occasional inspection and aspiration if necessary a window will suffice for this if the abscess is localized. The greatest care (p 145) should always be taken to avoid secondary infection of a sinus both by careful preparation of the skin with the special paint before, and at each dressing after its appearance Aspiration should always be tried but will seldom be effective in this region With the full precautions previously described free incision is permissible

For the periods of splintage in children in observation cases and for definite synovial and osseous disease see the programme described for the hip and the knee But there is one important difference in the later stages of treatment in that natural fibrous ankylosis is often stable enough to dispense with the need for arthrodesis Many children recover with movement



Fig 127 a.



Fig 127 b.

Figs. 127 a and b J.S Male aged 35 First seen after three months history of pain and swelling No radiographic signs at that time. In plaster for 18 months—X rays show subchondral erosion with small but deepish communicating foci.

2 **Operative.** *Extra-articular foci* When an opportunity of excision of a tuberculous focus occurs it should be carried out by an extra-articular route (b) *Astragalectomy* If the disease appears to be confined to the astragalus, astragalectomy should be performed Apart from these conditions treatment will depend upon the age of the patient In children and adolescents conservative treatment alone in plaster is as a rule, satisfactory In adults if the tuberculosis is uncomplicated by secondary infection, *excision and arthrodesis* is the rule This is best carried out at or toward the end of the second stage of conservative treatment preferably when recalcification has begun but it can be done earlier if special reasons so indicate

In older patients in whom the disease is serial and progressive (Fig 128) amputation is indicated at the site of election.

Technique

(*a*) **Astragalectomy** A tourniquet is used and the joint exposed through a curved incision on the outer side beginning behind the external malleolus and passing below it and up on to the dorsum of the foot The peroneal tendons are retracted the external lateral ligaments of the ankle divided, and the joint completely opened in front, laterally and behind The foot is now strongly inverted so as to dislocate the astragalus 90 outwards, and the bone freed from its ligamentous connexions with a gouge and knife and removed. In an early case in which disease is still limited to the astragalus great care should be taken *not to grasp the bone with strong bone-holding forceps* which though they may aid extraction, may also crush the thin shell of bone surrounding a tuberculous focus and set free infective material into the joint Synovial membrane if infected, is dissected away after removal of the astragalus and any foci in the tibio-fibular mortise curetted The foot is then displaced backwards so that the tibio-fibular mortise bestrides the tarsus in the region of the calcaneo-cuboid joint The mortise must be widened slightly by removal of thin malleolar bone slices if necessary to accommodate the tarsus at this point (or the tarsus may be narrowed) The final fit should be firm and the foot plantiflexed about 10 to 15° The tourniquet is removed haemostasis obtained the wound closed and plaster applied from just above the knee to the toes This plaster is split immediately along the midline in front of the ankle to permit of subsequent spreading if post-operative swelling interferes with circulation in the foot.

Astragalectomy can be made to give a satisfactory orthopaedic result especially in young children with a good prospect of freedom from recurrence Calvé[1] reports 12 mobile ankle-joints out of 13 cases of early astragalectomy in young children (2–8 years)

(*b*) **Excision and arthrodesis** A tourniquet is used and a similar incision made as already described for the operation of astragalectomy The fibula is divided obliquely with a fine chisel 2 inches above the level of the ankle joint and the external malleolar portion turned downwards hinging on

[1] Calvé Jaques, personal communication.

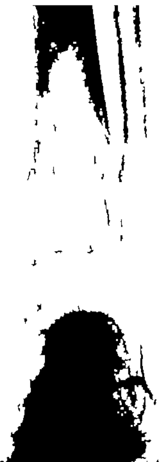


Fig 128 a.



Fig 128 b

Figs. 128 a and b H.T Male aged 22. History of 15 months of pain and swelling The X ray shows active tuberculous infection with intense reaction Secondarily infected sinuses resulted.

the intact external lateral ligaments. This opens the ankle-joint and the capsule is divided well across to the inner side anteriorly and posteriorly The foot is now forcibly inverted so as to dislocate the astragalus 90° outwards This is an essential step in order to obtain complete exposure of the ankle-joint The diseased synovial membrane is dissected away very thoroughly and all articular cartilage removed with a gouge (or if necrotic

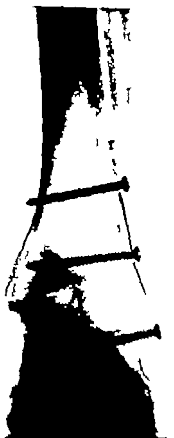


FIG. 129 Arthrodesis of the ankle using the fibula as a graft fixed in position with screws.

with a spoon) from the astragalus and the tibio-fibular mortise special attention being paid to the inner aspect of the internal malleolus and the corresponding astragalar surface The apposing bony surfaces are deliberately incised and roughened with a chisel or gouge The lateral aspect of astragalus and tibia is prepared as a graft bed into which the fibula suitably prepared is placed and lined securely in position with screws above and below the joint (see Fig 129) *Before* the graft is secured the foot should be held in the final position of some 10° to 15° of plantar flexion in order to fix the position of the ankle immediately The tourniquet is removed haemostasis obtained the wound closed and plaster applied from above the knee to the toes. This is split forthwith as described for astragalectomy

Other methods

In cases which no longer show any synovial reaction and there is no indication for a complete synovectomy an anterior approach and a graft from the tibia across the front of the joint into the astragalus is much less traumatic It is para articular rather than either intra-articular for the articular surfaces of tibia and astragalus are not fully exposed and bared nor is it extra-articular for the joint is opened in front

Alternatively in even more favourable cases an extra articular thick osteoperiosteal graft can be inserted from the tibia above the joint to the astragalus below in order to reinforce stability and favour the development of trans-articular fusion.

Ambulatory treatment

After the active stage and the need for general rest are over the patient can be allowed up with the ankle in plaster and the weight taken in a Thomas walking splint with a patten on the other boot or if an adult on a knee flexion peg leg

Result of treatment

This is satisfactory on the whole Younger patients and individuals without much involvement of bone when treated early may recover with mobile joints Ankylosis is more usual. There is much to be said for fairly early amputation at the site of election especially in adult wage-earners with extensive disease For conservative treatment alone or conservative surgery must mean at least two years treatment whilst amputation offers an earlier return home and even to work if conditions are favourable with the additional advantage of complete elimination of this disease focus But the associated lymphatic tuberculosis must not be forgotten (see Chapter I)

CHAPTER XII

TARSUS

TUBERCULOSIS of the tarsus occurs without much discrimination of age in the form of an insidious chronic inflammation with discomfort some swelling tenderness and warmth.

As a rule the infection is fairly widespread but occasionally there are isolated foci particularly in the os calcis or astragalus.

DIAGNOSIS

This is as a rule fairly straightforward from the clinical picture and from the radiographic evidence of decalcification which is locally rather widespread with perhaps evidence of erosion.

Differential diagnosis

This proceeds on standard lines. The only particular local abnormality which could be mistaken for tuberculosis is Köhler's disease an ischaemic osteochondritis of the tarsal scaphoid (Figs 132 and 133) This is one of the many instances of ischaemic disturbance of a bone nucleus due to embolism or thrombosis of an end artery Radiographs show the characteristic narrowing condensation (hypercalcification) and often fragmentation of the ossific nucleus In any of these the ischaemia may be due to an infected embolus pyogenic or tuberculous (see p 4) Such cases are very rare and distinguished by clinical and radiographic progress.

TREATMENT

The general treatment is standard and the local consists in immobilization of the whole foot and leg in a comfortable fitting plaster or splint The period of splintage and general line of treatment follow the principles which have already been fully described

Whenever there is evidence of localized disease of a single bone radical erasion of the focus or excision of the bone should be carried out, and if the astragalus is extensively involved without infection of the ankle-joint astragalectomy is indicated

The prognosis in tuberculosis of the tarsus or metatarsus depends almost entirely on the age of the patient In children the prognosis is very good. Conservative treatment almost always leads to healing with a reasonably normal and painless weight bearing foot In middle age amputation will save years of confinement Amputation is almost invariably indicated in patients above 40



FIG 130 *a* T.S Male aged 18 Complaining of persistent pain and swelling behind upper part of heel. Radiograph shows ill-defined cavity with sequestrum.



FIG 130 *b* Same case. After erasion. Tubercle bacillus found.



FIG 131 E.P Central tuberculous cavitation of the cuboid, well sealed off and the type of lesion which can often be successfully erased.



FIG 132. J W Originally simulated Köhler's disease but the ischaemia was due to a tuberculous embolus.



FIG. 133. B.S. Kohler's disease.

CHAPTER XIII

METATARSUS AND PHALANGES

In the authors experience tuberculous disease of the metatarsus and of the phalanges is almost confined to young children and the prognosis is good The local lesion is a relatively minor matter except as evidence of deep-seated lymphatic tuberculosis



Fig 134 Tuberculous dactylitis of the terminal phalanx of the great toe

DIAGNOSIS

Here again the picture is one of insidious inflammation with a little discomfort swelling warmth, and tenderness added to this are negative Wassermann and positive Mantoux reactions

In these small bones sequestration is relatively common

Differential diagnosis

Here there are two local oddities to be borne in mind

(a) March fracture (see Fig 133)

(b) Osteochondrosis of a metatarsal head (Fig 130)

TREATMENT

Incision of an abscess under the strictest precautions (see p 45) with excision or erasion of diseased or necrosed bone is indicated and protection of the foot from weight bearing until some months after the last sign of active disease

In young children it is seldom that anything more radical than sequestrectomy and curettage is required In adults however radical treatment is often preferable to prolonged immobilization particularly if loss of function of the infected part is inevitable



FIG 135. March fracture

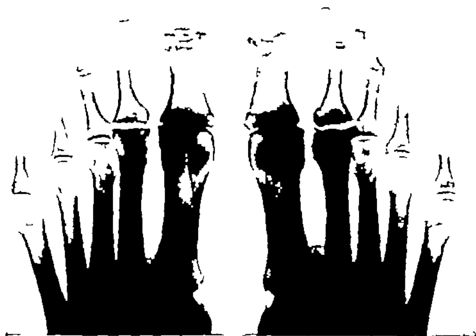


FIG 136. Osteochondrosis of metatarsal head.

CHAPTER XIV

SHOULDER

THIS condition is relatively uncommon. For example in a report from the Shropshire Orthopaedic Hospital out of 2 922 cases of bone and joint tuberculosis there were only 27 cases in which the shoulder was affected This is less than 1 per cent

Morbid anatomy

It is well known that the shoulder joint is a common situation for the atrophic type of tuberculous *caries sicca*, and this *in the authors experience* is rather more common in adults than the florid type with synovial thickening In the former case the lesion is osseous commonly superficial infiltration and erosion of the articular surfaces of the joint rather than deep-seated osseous foci In children, on the other hand massive lesions are more usual (Figs 137 *a* and *b*)

DIAGNOSIS

The clinical characteristics of a tuberculous shoulder differ markedly in the two types In both the history is of course of the kind already described and the patients complain of loss of function rather than of pain —

(*a*) ***Caries sicca*** The appearance of the joint is characteristic. The arm is held to the side and there is extreme wasting of the muscles round the shoulder particularly the deltoid. The patient cannot raise his arm from his side and will seldom move the scapulo-humeral joint at all. *On examination* there is almost complete limitation of all movement with perhaps a little warmth and tenderness

Radiographically there is decalcification of, and lack of definition in, the outline of the articular surfaces. Age incidence commonly the middle-aged or the elderly

(*b*) **Synovial type** *The characteristic features are swelling warmth tenderness and pain.*

The radiographic picture is that of decalcification without erosion (Fig 139).

Differential diagnosis

As described in regard to the hip q v perhaps special attention may be given to osteitis fibrosa (fibrocystic disease), osteoclastoma and sarcoma also traumatic arthritis Codman s Shoulder [1] and a subacute form of staphylococcal osteitis.

Staphylococcal infection The authors have on several occasions seen a very chronic form of staphylococcal osteitis of the neck of the scapula with

[1] Codman, E. A. *Th Shoulder Rupt re of the Supraspinatus Tendon and other Lesions in or about the Subacromial B rsa* Thomas Todd Boston, Mass., 1934



Fig. 137 *a*.

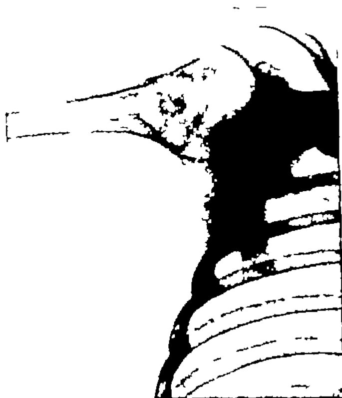


Fig. 137 *b*

Figs. 137 *a* and *b*. D.P. aet. 3. *a* = ix.24. Note density of the epiphysis of the humerus, denoting a vascular catastrophe in this instance due to a tuberculous embolism. *b* = x.23. Subsequently a secondary lesion developed in the spine.



FIG 138. Male aged 38 One year's history Pain particularly at night On examination wasted and immobile shoulder Radiographically unsound ankylosis.



FIG 140 M.C Woman with 3 years history following pleurisy



Fig 140 Osteoclastoma.



Fig 141 Syphilis.

general swelling round the shoulder without much pain, but with complete limitation of movement Actually this is more likely to be mistaken for a sarcoma than for tuberculosis. At the same time it should be borne in mind whenever one is presented with an immensely swollen stiff shoulder



Fig. 142. Osteoarthritis of this severity is uncommon in the shoulder but is sometimes seen following Caisson disease.

TREATMENT

General

As this is the first non weight-bearing joint with which we have had to deal this perhaps is the most suitable place to discuss the problem of hospitalization We believe that all would agree that children should be kept in hospital for general treatment and that the shoulder should be immobilized in the position of choice, but there are those who believe that adults can be at home if conditions are satisfactory and carry the forearm in a sling

The authors look upon every patient with a recent tuberculous lesion as seriously ill and needing general treatment for at least two years This of course does not mean that the patient must always be retained in hospital But to begin with he should be admitted put to bed and investigated thoroughly for signs of tuberculosis elsewhere a series of E.S.R. tests should be taken and his temperature chart studied This also gives time to make sure of the comfort and efficiency of his local splintage After this period his treatment will depend upon his home conditions and his health and vitality

but the authors believe that it is our duty to do the utmost possible by moving him to a favourable climate particularly in the winter and by inculcating a healthy régime of life

It is true that the prolonged splintage of the shoulder is not well tolerated by an adult But in uncomplicated cases where the period of external splintage can be shortened by arthrodesis there seems no adequate reason for abandoning the principle of splintage in the position of choice However complications such as pulmonary disease or exceptional considerations may indicate the use of a sling The position can be corrected later by osteotomy

Local *Thoracobrachial p*

The form of splintage found best by the authors is a body and arm plaster (Fig 143 *a*) The more extensive the hold such a plaster has upon the body *the more comfortable* is the splint and the more effective is the immobilization The splintage is really built up upon the pelvis and the weight of the arm is transmitted to a well padded firm hold of the pelvis A large anterior window can be cut out The arm is held in a position which is modified in accordance with the age of the patient In young children this is 90° abduction 30 flexion and about 20 external rotation with the elbow at a right angle and the wrist supinated The hand is always much more comfortable if the plaster is carried well down to support its ulnar side

In adults in whom the scapula is less mobile the position is 70 abduction 40 flexion and as much external rotation as will ensure that flexion of the elbow will bring the fingers to the mouth.

In young children more abduction and more external rotation can be allowed on account of the greater mobility of the scapula It is also probable that any fixation that occurs naturally will be fibrous and will tend to give way in the direction of adduction as time passes.

Period of splintage

(*a*) Synovial In cases where the diagnosis is almost certain the splintage is continued without interruption for at least a year and always some months after the disappearance of all swelling and heat If at this period, there is no radiographic evidence of osseous foci the lid of the plaster is removed and active and gentle passive movements encouraged The success of this treatment is judged by Thomas's standards (p 40) and if the results are encouraging, a light aeroplane splint is substituted for the plaster and week by week a further range of movements allowed.

N B In cases where the diagnosis is observation shoulder the whole process can be speeded up

(*b*) Osseous Here the period of splintage is governed by the radiographs. The shoulder is a non weight bearing joint and not subjected to the great strains and stress of the knee and the hip One can therefore particularly in children be satisfied with a fibrous ankylosis which would be dangerous in a weight bearing joint Even in cases where there has been considerable

destruction the splintage can be gradually remitted on the lines described above provided that the patient can maintain abduction. It is this maintenance of abduction either by active movements or by the control of a sound fibrous ankylosis, which is the aim of splintage and which may call for continued splintage long after the disease has apparently been arrested On the other hand in older children excision of the diseased soft tissues with



FIG 143 a. Thoraco-brachial plaster showing the arm held in the optimum position.

erasion of the bone foci may have to be carried out, and arthrodesis is frequently indicated This may be achieved by some form of intra-articular arthrodesis almost always associated with an extra-articular osteoplastic or graft synostosis After such an operation splintage in plaster is necessary for six months to one year, and the position chosen will be midway between those described on p 255 for children and adults.

The difference in the local treatment of adults is that arthrodesis is carried out at a much earlier stage The general indications are the same as those for the hip and the knee in that it is advisable before operating to raise the general resistance of the patient and to reduce if possible the activity of the local disease

In the florid form, it is the authors practice in adults to carry out a thorough excision of diseased soft tissues the erasion of osseous foci and arthrodesis



Fig. 143 b.



Fig. 143 c.



Fig 143 d

Fig 143 e

Figs 143 b c d and show range of movement after arthrodesis in position of choice

Technique of operation

(1) **Excision and intra-articular arthrodesis** Incision Skin flap turned up exposing deltoid The deltoid muscle is detached widely with its periosteum of origin and turned down The shoulder joint is opened the infected synovia and all the tuberculous granulations and debris removed

The head of the humerus is remodelled with the object of producing the largest possible surfaces of healthy bone directed toward the scapula Next the glenoid is cleared of cartilage leaving a vascular bony surface The acromion is then carefully split well back into an upper and a lower leaf The lower leaf is turned down in the form of an osteo periosteal bone flap to meet the upper edge of the glenoid with its raw surface toward the humerus

The operation is then completed by fitting the adapted surface of the head into the socket formed by the acromion the pedunculated acromial flap and the glenoid Close apposition must be maintained and it is possible to favour this by a suitable strong catgut stitch to maintain the parts in apposition until the plaster has been applied

The deltoid is sutured back onto its origin with chromic catgut and the skin wound sutured without drainage The arm is put in plaster and joined to the body case (applied before operation) Position 70 40

(2) **Extra articular arthrodesis** (*a*) *Watson-Jones technique* Exposure as above the joint capsule is not opened The acromion is denuded of periosteum on the upper and lower surfaces A cleft is made in the great tuberosity of the humerus by driving a chisel into it in the sagittal plane and levering the fragment out but not fracturing it off The base of the acromion and the outer end of the clavicle is nearly cut through with a chisel so that the acromion can be angled down and its rawed end impacted into the cleft in the great tuberosity when the arm is abducted to the required angle The wound is closed and the plaster completed as above

(*b*) *Low arthrodesis* Posterior axillary arthrodesis (Brittain 1942)

The approach is posterior and the method consists in placing a stout tibial graft with one sharp end impacted into the shaft of the humerus and one bifid end fixed against and partially mortised into the axillary border of the scapula This is a low (distal) extra-articular arthrodesis and very closely analogous to the Trumble method of ischio-femoral arthrodesis of the hip The authors have tried it in one case only but feel that it is likely to prove a good method for those cases of healing tuberculosis of the shoulder in which a local excision is not necessary It eliminates any risk of secondary adduction.

The elderly

In the elderly the prognosis is poor and it is probably wise to leave the patient with his arm in a sling and to be guided as to operation by the activity of local disease If the condition is a mild one there is fair hope that the inflammation may become quiescent for a time at least with a sling and good



Fig. 144. Extra-articular arthrodesis. Watson-Jones technique

Fig. 145. Low arthrodesis. Brittain's technique. Incorporation and consolidation of the graft is complete and the disease healed.

general treatment If however there is a more florid type of disease excision may become necessary but operation should be avoided if possible

These older patients are as a rule widely infected with tuberculosis their physique and vitality rather than their years must be our guide actually the humbler objective of a quiescent joint with the arm at the side—an aim which is often within reach by conservative measure—is generally preferable to excision and arthrodesis because the excision with the after splintage is not easily borne and the fusion will often fail

Operations with end-results

The following table shows the results of a series of seven cases of tuberculosis of the shoulder treated by conservative plus operative methods in the Wingfield covering a period of twelve years

TABLE 26

Name	*M or F*	*Age*	*Length of history*	*Type of operation*	*Result*
G.B.	M.	51	1 month	L.A.A. + acromial flap	Fibrous ankylosis.
A.H.	M.	35	1 year		Fibrous ankylosis (died of meningitis 16 months after).
K.K.	M.	16	1 year		Fibrous ankylosis. Working
L.M.	F	23	2 years		Untraced.
A O	F	13	7 weeks	,,	Firm fusion.
M.R.	F	45		Excision of head and upper 2" of humerus.	Very good. Mobile.
A.S	F	38	8 years (approx.)	L.A.A. + acromial flap	Firm fusion.

CHAPTER XV

ELBOW

In a period of fifteen years sixteen cases of tuberculosis of the elbow have been treated at the Wingfield Morris Orthopaedic Hospital But the elbow though a complex joint is relatively free from all forms of arthritis other than those following injury or occupational stress So much so that an insidious mon-articular arthritis of the elbow is more likely to be tuberculous than in most other joints. Furthermore the disease is commonly synovial in the sense that there are often no radiographic signs, particularly in the first two or three decades of life Curiously enough the elbow is very seldom subject to the transient arthritis associated with pharyngeal or intestinal infections during childhood, and it is far less liable to that form of chronic non-tuberculous arthritis which is a common and stubborn affection of the wrist in young adults So that on the whole any case of arthritis of the elbow of insidious origin must be regarded with grave suspicion and treated promptly and very carefully under a provisional diagnosis.

Morbid anatomy

If there are osseous foci in the neighbourhood of the elbow they are most often found in the ulna

DIAGNOSIS

Here again the clinical picture is of standard type In the young patient there are always swelling, warmth tenderness, and pain on movement with considerable limitation of its range by muscular spasm.

Differential diagnosis Standard (*vide* pp 10 et seq)

TREATMENT

General. Standard (*vide* pp 27 et seq)

Local

I **In children and adolescents** prolonged conservative treatment is almost always adequate

For complete immobilization a thoraco-brachial plaster is necessary, but during convalescence a plaster from shoulder to palm with a close fitting shoulder cap above In both plasters there must be control of radio ulnar movements. The angle of posture should be a few degrees above that ultimately desired This varies slightly according to the patient's occupation and wishes. One can begin with the elbow just above a right angle and the hand slightly pronated



Fig 146 a.



Fig 146 b

Figs. 146 a and b T.S.B. Male aged 50 Extensive tuberculosis in elbow joint.



Fig 147 a.



Fig 147 b.

Figs. 147 a and b. Male aged 48 Osteoarthritis.

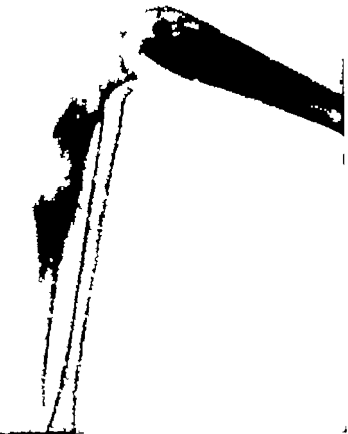


FIG 148 a.



FIG 148 b

FIGS. 148 a and b Tertiary syphilis.

(*a*) In cases without radiographic evidence of tuberculosis in which the diagnosis remains *sub judice* the plaster is kept on for some months after the last sign of warmth, tenderness, or swelling has disappeared, and then replaced by a sling This is retained for a test period on the usual standard tentative plan. *If movement progressively increases all is well If not* prolonged immobilization is indicated

(*b*) Whenever there has been disorganization of the joint one aims at bringing about sound fibrous ankylosis in children but in adults *bony fusion by* excision and arthrodesis.

The angle of fixation must be chosen in view of the occupation of the patient and the service which he most desires from the affected limb It varies between 80 and 110

II **In the middle-aged and elderly** (*a*) *Synovial* Treatment is at first conservative as described above But even if at the end of a year or so the inflammation appears arrested, immobilization must be kept up for a very long time and it is well to replace the plaster by a moulded leather splint which may have to be worn almost indefinitely If progress is less satisfactory excision and arthrodesis is advisable

(*b*) *Osseous* Here again conservative treatment as above should be tried. But in cases in which clinical signs and radiographs suggest that the main *disease is osseous, a limited erasion and curettage of these lesions without wide* exposure of the joint may be worth while, as an incident in the conservative treatment and in the hope of eliminating the need for formal excision

Excision and arthrodesis Incision a long curved postero-internal incision is made centred on the joint and beginning and ending in the midline behind

The triceps is split and dissected off the condyles of the humerus, and the upper ends of the radius and ulna are cleared keeping very close to the bone and taking the greatest possible care not to damage the ulnar nerve in its fibrous bed. The nerve is *identified though not fully exposed* and very carefully and gently retracted with its surrounding soft tissues out of the way with the *least* possible retractor pressure and without of course *ever picking up or touching the nerve with the forceps. In order to open up and expose* the interior of the joint the posterior joint-capsule and synovial membrane are *dissected away and the elbow strongly flexed* All pus debris and infected tissues are removed and all synovial pouches carefully dissected away special attention being paid to the reflections round the neck of the radius. The articular cartilage is removed completely from the humeral radial and ulnar surfaces This may require the use of a gouge but the cartilage often peels off readily with a curette The bone surfaces left above and below should be vascular and as broad and well adapted to each other as possible

A tourniquet has been used and this is now removed or released and haemostasis is obtained The bone ends are then fitted into close apposition with the elbow in the position of election muscular aponeurotic and skin wounds *are closed without drainage and plaster applied*

Splintage following an operation for arthrodesis of the elbow necessitates



FIG 149 a. F.K. Male, aged 21 Eighteen months history; tuberculosis of elbow



FIG 149 b Same patient 4 years after excision and arthrodesis.

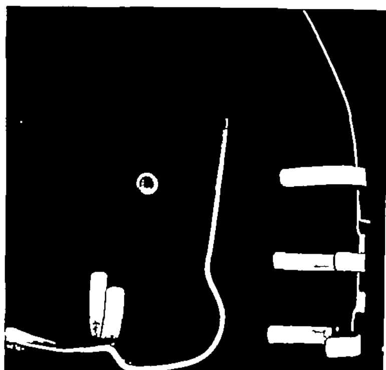


FIG 150 a.

a thoraco-brachial plaster and it is always wise to have the thoracic part of the plaster put on forty-eight hours before the operation This is valuable in two ways. First in that it can be made to fit with greater accuracy and com



Fig 150 c

Figs. 150 a b c. (a) Apparatus for impaction of elbow after arthrodesis, before assembly (b) Apparatus incorporated in shoulder spica. The plaster around the elbow had been removed and the gap covered with a loose cotton bandage. (c) X-ray showing position of the elbow in plaster with the bony surfaces held in close apposition.

fort if it is done with a conscious patient than is possible at the end of an operation with the patient under an anaesthetic Secondly the post-operative control of the arm is easier when all that is necessary is to build an arm plaster onto an existing thoracic shell. Fig 150 b shows the plaster in place Attached to it is a gadget shown in Fig 150 a which enables one to apply a slight steady compression of the ulna up against the humerus. This gadget is applied after the brachial part of the plaster is completed and subsequently a section of plaster round the elbow itself is cut out so that the control of the forearm is dependent entirely upon the lower segment of the gadget which can be subsequently drawn up by the screw attachment (comparable with compression arthrodesis of the knee see p 220)

CHAPTER XVI

THE WRIST

The morbid anatomy differential diagnosis and general treatment need not be restated formally a few local considerations are dealt with below

Various parts may be infected

1. The radio-carpal joint
2. The inferior radio-ulnar joint [1]
3. The carpal bones and intercarpal joints.
4. The compound palmar ganglion—or other tendon sheaths

Synovial disease of the wrist presents a characteristic appearance but diagnosis may be difficult because the wrist is prone to suffer from a peculiar form of arthritis of unknown origin (but of a rheumatoid type) This in its chronicity and its clinical picture is only to be distinguished in that there is not the decalcification of tuberculosis It is very troublesome even more chronic and less likely to become quiescent than tuberculosis and in such cases after perhaps, a year or more of plaster immobilization the surgeon is driven to one of two courses—either immobilization for an indefinite period in a reinforced moulded leather splint or arthrotomy for diagnosis and perhaps arthrodesis The wrist is of course also commonly affected by the *ordinary polyarticular rheumatoid arthritis*

Osseous disease. It is dangerous to be dogmatic regarding a relatively rare disease but a widespread carpal infection seems common when the infection is evidently osseous

The carpal bones seem prone to tuberculosis in the elderly and this is often of a very destructive type with sinus formation and secondary septic infection The hand and wrist become swollen and burrowed by infected sinuses.

The carpals metacarpals and phalanges are fairly commonly involved as part of that multiple small bone tuberculosis which occurs in young children particularly *Here there is often relatively early abscess and sinus formation* Fortunately these cases do well with general treatment with perhaps an accent on heliotherapy

The inferior radio-ulnar joint may be infected with the radio-carpal joint or more rarely be infected alone Occasionally it is affected by that odd condition of chronic arthritis associated with innumerable tiny melon seeds which is perhaps not always due to tuberculosis In the few cases the authors

[1] Liebolt (*Surg Gynec and Obst.*, 66, 1938, 1009) has recorded a 30·4 per cent frequency of associated infection of the lower end of the ulna with that of the wrist joint in a series of 23 cases, and 30 6 per cent frequency of perforation of the triangular fibro-cartilage in a series of 100 wrists examined post mortem. He suggests that the fibro-cartilage is ordinarily a protection against the spread of infection.

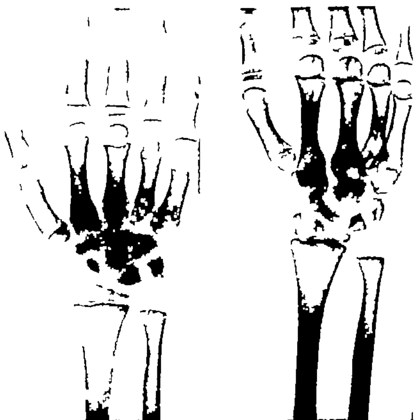


Fig 151 *a* Fig 151 *b*

Fig 151 *a* D.S.P. Boy aged 4 Extensive tuberculosis of the carpal bones involving bases of the medial four metacarpals. Discharging sinus.

Fig 151 *b* Same case 3 years later Recalcification and reconstitution of carpal bones as a result of long-continued general treatment.

Fig 152. S.A Male aged 31 Four years history Discharging sinuses. X-ray shows extensive destruction of wrist and carpal joints as a result of tuberculosis.



Fig 152.



Fig 153 a



Fig 153 b

Figs 153 a and b E.M B Rheumatoid arthritis.

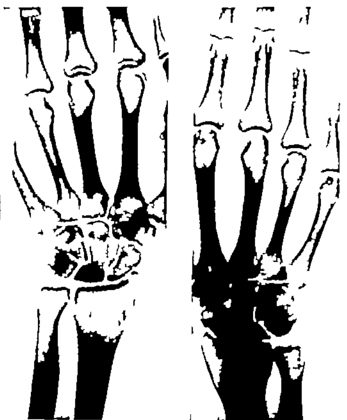


Fig 154 Bilateral Kienboch's atrophy The appearance of disease in the right wrist followed nine months after the left.



Fig 155 B C. Woman aged *8 Three years history of chronic arthritis occurring in a single joint Histologically not tuberculous.

have seen, a synovectomy which was as complete as could be managed wit preservation of the joint followed by a few months immobilization, has bee successful

TREATMENT

Synovial disease

Primarily conservative a close-fitting plaster case from just below the elbo to the knuckle-joints holding the wrist in about 30 of dorsiflexion. The elbo must be included if it is desired to immobilize the lower radio-ulnar join *In cases definitely tuberculous immobilization must be kept up for at leas a year after* the last symptom or sign of activity has gone *and* until there i *radiological evidence of healing* (clear outlines and advanced recalcification)

In young children the outlook is promising but in older patients, or whe there is advanced disease of the carpal bones operative treatment is com monly necessary

Operative

(*a*) **Arthrodesis** in order to promote sound healing in a joint in which th active disease has been arrested This may take the form of extra articular grafting between the radius and the first line of carpal bones. This operatio is not truly extra-articular because in the preparation of the raw bone th joint is open At this point the opportunity should be taken of erasing an diseased material

The graft used is a stout osteo-periosteal graft from the tibia (Figs 156*a* and *b*)

(*b*) **Excision and arthrodesis** In this operation the first step is a synovectomy as complete as possible together with the erasion of the lower surface of the radius and the removal of any extensively diseased carpal bones If possible a raw surface of healthy bone is brought into contact with the lower end of the radius It is best to add posterior osteo periosteal grafts

(*c*) **Excision of all the carpal bones** leaving a mobile false joint (Fig 157) This is often the wisest procedure

After-treatment

Plaster as for conservative treatment

N.B In this as in all post-operative plasters a vertical split is made to allow for subsequent swelling

In cases where there have been heavily infected sinuses they must be opened and drainage maintained. Young patients do well healing almost always follows and if the hand has been kept in the right position (see below) good function follows But in old people the disease may be so widespread that adequate drainage is impossible Indeed one must confess that hateful as it is amputation occasionally *has to be done for extensive secondarily* infected disease in the wrist and hand of an old person



FIG 156 *a*.



FIG 156 *b*.

FIGS. 156 *a* and *b* Arthrodesis of wrist for tuberculosis.



FIG 157 W.K Male aged 32 After excision of carpal bones for tuberculosis.



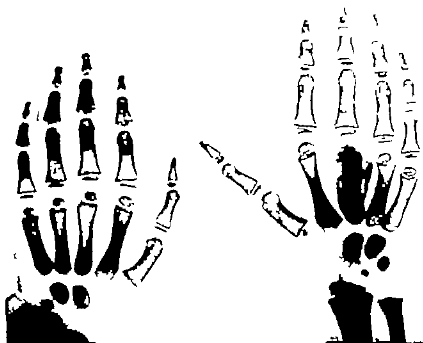


Fig 159 a Child aged 4 Tuberculous dactylitis. Treated by curetting of abscess and suture of skin incision.

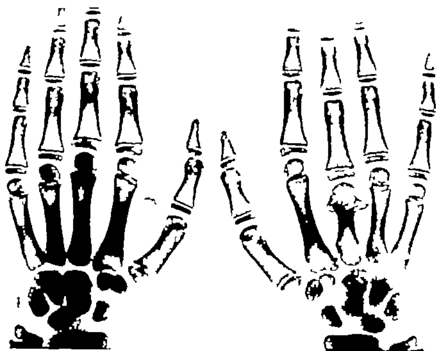


Fig 159 b Same case 5 years later

In all cases where a hand is to be immobilized for a long time on account of extensive septic infection, it is vital that the thumb and fingers should be accurately opposed from the very beginning The best position is with the wrist in 10 or 20 of dorsiflexion the thumb abducted and partly opposed with the interphalangeal joint free (or if the area of disease allows with both its distal joints free) The other metacarpo phalangeal joints should be free to flex or if they must be held, held in a position of at least 30 of flexion.

These points are mentioned because so many of these cases are put upon straight splints with the hand flat and the metacarpo-phalangeal joints fully extended this is a bad fault since it involves prolonged perhaps permanent loss or diminution of function the need for much prolongation of treatment and a great deal of pain in the subsequent efforts to restore mobility All this can be avoided.

Indeed when one remembers the experience of the old days and the teachings of the early years of this century as regards operations on the wrist for tuberculosis and particularly wide resections without arthrodesis in comparison with those of the present day one realizes the importance of orthopaedic immobilization and after-care In the past various operations were tried and almost all failed and in a great many cases the hand was eventually amputated as a result of inadequate immobilization in a bad position.

CHAPTER XVII

THE HAND

FOR the morbid anatomy and diagnosis see Metatarsus and Phalanges

Treatment too is similar except for the very important matter of posturization of hand and fingers (see above) and the great value of preserving every part of the hand to which function can be restored The sacrifice of a finger or of a metacarpal is however infinitely preferable to a risk of the infection spreading into the carpus or the common tendon sheaths



FIG 160 Compound palmar ganglion.

Tendon sheaths

The tendon sheaths particularly the compound ganglion tendon sheaths of the hand and wrist are liable to subacute or chronic tenosynovitis of the melon seed variety There is as a rule an enormous distension of the sac by innumerable small seeds, which arise from the synovia The synovia itself is thickened and a granulomatous infiltration surrounds and penetrates into the tendons (Fig 160)

Operation is inevitable and involves a prolonged and difficult dissection At the end of such an operation one often feels vaguely dissatisfied and on the horns of dilemma for since the elimination of the infective infiltration cannot have been microscopically complete the fingers should be immobilized long enough to satisfy the standard principles of the treatment of tuberculosis yet this is clearly incompatible with the restoration of free

mobility Fortunately however this type of synovial disease responds favourably to a relatively short period of immobilization say about *six weeks* The hand is of course immobilized in the position described and illustrated on p 176

Much more rarely the tendons of one or more fingers are involved Here again operation is inevitable and once more the dissection involved is so extensive that the preservation of the finger or fingers seems futile At the same time it is worth attempting (Case E H)

Case E.H. Age 28. Male.

First seen 22.x.37 with immense swelling of the first and second fingers, fluctuation, and melon seed sensation.

History Two years slow progressive increase in swelling Movements of the affected fingers much limited, though the limitation appears to be entirely due to the swelling and there is no pain or rigidity 5.xi.37

Operation. Incisions made on the radial side of the index finger and ulnar side of the middle finger prolonged into palm. Skin flaps reflected carefully avoiding the digital nerve and vessels. Flexor tendon sheaths exposed and found to be greatly thickened On opening the sheaths a large number of small round melon seed bodies were evacuated, more numerous in the index than the middle finger sheath The thickened tendon sheaths were dissected out as completely as possible in their whole length The operation was done under a tourniquet which was released for a period at 30-minute intervals. Skin wounds sutured

Section shows small tubercles with infrequent giant cells with much round-cell infiltration Returned as definitely tuberculous of low grade type.

19.xi.37 Fingers put in plaster in semi flexion.

10.ii 38 Much less swollen, no local heat some increase in range of movement. To leave off splint and give the fingers natural use.

8.vi.39 Has been in active work as chauffeur during the last four months.

CHAPTER XVIII

TUBERCULOSIS OF SKELETON AND LUNG COMBINED

THESE cases are commonly found in one or other of two groups —

GROUP A

Patients under treatment for skeletal lesions who are found to have active pulmonary disease

As an initial lesion in young children

Dr Kalman Mann s (1945) admirable presentation of the frequency of Primary Lung (and Gland) complex in young children leaves us more than ever conscious of the importance of this subject As the elimination of bovine infection by pasteurization of milk becomes more effective the invasion of the lung by inhalation is likely to be the common manner of entry In pre-pasteurization days the bovine bacillus was responsible for 85 per cent of skeletal tuberculosis in children under 5 Dr Mann s figures show a complete reversal with the human bacillus responsible for 85 per cent of the cases in this age-group These figures are revolutionary but we must remember that they refer to cases coming from an area in which the milk is pasteurized and during a period in which great shortage of beds kept many highly infective parents in their homes

In the great majority of Dr Mann s children primary (air borne) lung invasion has replaced primary (milk borne) lymphatic disease It is more easily demonstrated but at this age seems to be about equally recessive where the patients are well cared for in an open-air orthopaedic hospital.

Diagnosis is made by routine radiography of the chest in all cases suspected of tuberculosis anywhere this is carried out on admission when negative repeated in two months when positive repeated periodically In doubtful cases the examination of sputum or stomach washings for tubercle bacilli may clinch the diagnosis.

Treatment. The general treatment already begun of rest in bed in the open air will suffice in the great majority of the patients. Perhaps even greater precaution should be taken in the use of heliotherapy (see p 128) In some cases, however the chest lesion may develop and become a serious factor and this may be evidence of a general failure in reaction For the treatment of these patients and all others in whom the diagnosis of established pulmonary disease is made (by radiology and all the standard methods) the chest physician will co-operate with the orthopaedic surgeon. Sometimes operation on the skeletal lesion may have to be postponed on account of

active chest disease more rarely the radical extirpation of a major and very active skeletal focus may be indicated to reduce toxaemia and favour the development of the patient s resistance (case D.F)

The Prognosis in Group A then remains favourable in those patients whose primary complex proves quickly recessive but it is much depressed by an established active lesion—probably the mortality is multiplied thereby three or four times An example is provided by Seddon and Strange in their statistical report on sacro-iliac tuberculosis they give a mortality of 10 per cent in uncomplicated closed lesions and 55 per cent in cases with other tuberculous foci. Perhaps this form of investigation is liable to present the facts rather unfavourably There should be no pessimism rather a determination to achieve the fullest co-operation between the experts in the treatment of pulmonary disease and ourselves

GROUP B

Patients under treatment for pulmonary tuberculosis who develop skeletal lesions.

How does the appearance of skeletal lesion affect the prognosis of a patient under treatment for pulmonary tuberculosis?

If we exclude those cases in which the appearance of a skeletal lesion is just the manifestation of a general breakdown of resistance it is probable that in the majority with the co-operation of an orthopaedic surgeon experienced in tuberculosis and with the means of combined treatment to hand the previous prognosis *as regards life* whatever it has been will not be adversely affected Paradoxical though it may seem the patient s prospect of recovery may actually improve An explanation is suggested later The patient may indeed lose the function of his joint may perhaps even lose his limb but not his life The success of the combined treatment depends a good deal upon there being the right sort of hospital or unit in which the specialists on the chest and on the bones and joints can work together

Treatment. A tuberculous joint may be treated by Rest enforced un interrupted and prolonged it may be excised and its bony elements adapted and coapted for fusion or it may be amputated The answer to the question How does the pulmonary lesion affect the treatment of the joint? can only be given for each individual patient *one at a time* after careful consideration of the whole clinical picture of the case It is a matter of consultation experience and judgement Nevertheless a few hints can be given and some examples considered.

(*a*) With the shoulder the advisability of a big thoraco brachial plaster controlling abduction flexion and rotation will be questioned the decision will vary but will be more often no than yes

(*b*) Where the spine is involved there are special difficulties Various methods achieve immobilization and at the same time allow the physician

the access he requires such as the plaster bed with a turning case the Robert Jones frame with a turning case or as has recently been found invaluable the Hey Groves bed with its two alternative mattresses temporarily clamped together one above one below the patient for his turning

(c) Long spica plasters for sacro-iliac joint or hip and the shorter spica for the knee should maintain their hold accurately though turned from supine to prone and back again as often as may be required by the physician

It will be asked What is the bearing of the big plaster on the patient s pulmonary disease ? of his lying so long in the horizontal position ? and of his being kept in hospital months or years longer than he would have been for his chest alone ? If rest is as good for the lung as it is for the joint and if good food and an open-air régime on a good site are better for the patient than the average home then the answer must be that the slow conservative treatment of a major joint is if successful favourable to the final healing of the lung and the recovery of the patient

Operative Treatment

On the whole it is true to say that in the presence of an active pulmonary focus there is less margin for trial and error than in uncomplicated cases Treatment must be well planned this calls for a discerning assessment of the existing tuberculous invasion and a capacity to foresee the probable out come of several different lines of treatment these are gifts which are the reward of experience observation, and understanding However carefully a programme may be foreseen and planned it must be periodically reviewed by the team in the light of events. For example amputation may be advanced if the patient fails to gain ground, or if reaction is good delayed perhaps reconsidered.

As regards adults we know that however admirable the operative technique may be in excision and apposition with a view to fusion (with or without grafting) of the hip or knee union is unlikely if the tuberculous patient is say over 40 and ill, or if the local lesion is active A surgeon can carry out the operative preliminaries favourable to arthrodesis but sound bony union depends on the health and vigour of the patient A fusion that will not fuse is a long miserable and most disheartening business

The timing of a major operation may have critical importance We regard the rise or fall of the sedimentation rate as a valuable indicator of the success or failure of reaction. Then as regards the operation shock can be minimized by gentleness accurate haemostasis the replacement of blood lost by blood transfusion and the drawbacks of inhalation anaesthetics avoided by the use of spinal and intravenous anaesthetics

The following is a recent and excellent example —

Miss D P., aged 16 sent for consultation, July 1945.

193 Swelling right knee.

1939 Tubercle bacilli aspirated in fluid from the knee.

December 1939 X ray of chest showed minimal infiltration of left apex.

December 1942. Increase in the disease left apex and slight infiltration right apex.
February 1943. Left A.P done.
January 1945. X ray showed small cavity right apex.
January 1945 Right A.P done.

In January 1945 and again in July 1945, she had been seen by an Orthopaedic Surgeon who advised excision fusion. When seen by one of the authors (G R. G) in July the knee was in plaster it was hot, swollen, and tender There was lateral mobility and X rays showed erosion of the articular surfaces and extreme decalcification. Her E.S.R. was 27

A letter was written as follows:

This girl presents a very serious problem indeed It would appear that her tuberculosis has been, on the whole rather insidiously progressive, and that she has never proved herself capable of putting up adequate resistance. Her sedimentation rate is now raised and her knee is very hot and much swollen. The X rays show an active process of erosion and decalcification. There is probably active infiltration going on.

Three questions arise:

(1) Is there any hope of a mobile knee? The answer is easy—absolutely none taking into consideration her age and clinical picture.

(2) Should arthrodesis or amputation be done? The answer to that question cannot be given at the moment. I am quite sure that arthrodesis at present would fail absolutely and the operation would be fruitless. Unless and until local condition responds definitely *and progressively to complete rest an attempt at arthrodesis would be completely futile* It seems, on the whole, more than likely that in this case, and with this picture amputation will be necessary but I do not think that any operation of this severity is indicated at present and it may well be impossible to make a choice between excision and arthrodesis on the one hand and amputation on the other until the evolution of the disease is clear If it should be that despite general measures and complete immobilization the active destructive process goes on with undiminished activity amputation may well be indicated as a necessary measure.

Miss F raised the matter of the alternative of remaining in a sanatorium or coming to the Wingfield Morris Orthopaedic Hospital, where we take a great deal of surgical tuberculosis and have the valuable help of Dr Stobie as consultant on the medical side As this girl has not got any open tuberculosis she would be a perfectly suitabl case for treatment here if you think this plan best.

I am sure you will agree that in a case like this the exact timing, as well as choice of operation, is a matter of great importance Please let me know if you would like me to arrange her admission when we have a bed available in the private wards

She was admitted to the Wingfield on 25.ix 45 and put in a spica plaster giving complete immobilization to her knee without any constriction. While she was in the Wingfield Hospital Dr Stobie was good enough to take over from Dr Todd the supervision of her pulmonary condition and carried out the refills of her right and left A.P's

Two months later there was little or no diminution of heat tenderness, or swelling Accordingly on 4.x 45 one of the authors (G R. G) amputated the limb through the thigh at the site of election, and as he did so was glad he had taken that decision for in addition to the widespread disease of the bone shown in the X-ray film, there was a large abscess burrowing extensively up the thigh and infiltrating the muscle tissue of the quadriceps. This involved a wide dissection both of the abscess and the diseased muscle For all amputations at the site of election in the thigh he uses an anterior plaster plaque covering the abdomen and anterior half of the stump in order to maintain immobilization in the anatomical position In such a case as this there is more than the usual advantage in this procedure

Her anaesthetic admirably given, was a hemi-spinal with enough pentothal to keep the patient asleep. Her condition was undisturbed by the operation. Her progress has been very satisfactory. She returned to Dr. Todd on 9.xi.45, able to get up on crutches and be completely at his disposal.

Occasionally there may be grave doubt as to the advisability of an operation in the presence of extensive pulmonary disease.

Mrs. H., aged 58, came under the care of one of the authors (G. R. G.) on 15.iii.41, a patient of Dr. Adamson and Mr. R. Young of Glasgow.

In the summer of 1939 she began to complain of pain in her back and round her abdomen. This was very severe at times and aggravated by movement. This went on and Mr. Young, who saw her in February 1941, found that she had extensive changes suggestive of caries in the 12th dorsal and the 1st lumbar.

Dr. Stobie reported on her chest: Old standing fibrosis, cavitation left upper zone, wide displacement of mediastinum. A few signs only right upper. X rays show more disease on right side than clinical examination reveals. Disease is active in a chronic sense, accounting in part at least for temperature range, pulse-rate and sedimentation rate.

Impression. A woman old for her years with advanced pulmonary tuberculosis.

Recommendation. Rest with or without plaster bed. General treatment. Prognosis poor. Not only was there a severe spinal lesion but all her bones showed the extreme decalcification we sometimes see in elderly women without any discoverable disturbance of biochemistry.

As time passed it was clear that her present condition was miserable, with little prospect of betterment. It proved impossible to give her relief or comfort either free in bed, on a frame, or in a plaster bed, and her spinal pain persisted with her cough.

Grafting became more and more obviously desirable, yet the contra-indications seemed so strong—her debility, decalcification, age, and the very poor prognosis. On the other hand the possibility of giving her relief from her pain by the internal splintage of successful posterior spinal fusion and of thus enabling her to be bedridden in comfort ultimately overcame reluctance. Accordingly, on 19.v.42, operative posterior spinal fusion was performed by double tibial grafts into trident spinous processes of the diseased vertebrae and one healthy vertebra above and below.

Though the tibial cortex was very thin her subsequent progress at the time and since has been admirable. She quickly lost her pain, and by early November she was free in bed. In December 1942 her notes say: doing well! Free in bed since early November, but of course the prognosis is still very poor. Though at least she has freedom from pain and it is possible she may get up awhile. In July 1943 she was up and walking, and went down to her home on the south coast.

In October 1943 she wrote:

I feel remarkably well and never tire of the simple joys of getting up and wandering about as I please unheeded. The following summer she came to Oxford and gave a party to some of the nursing staff who had cared for her in hospital.

This must not be regarded as a standard result! At the same time it is well to record it here because it illustrates the extraordinary capacity for recovery some patients possess, and still more because it argues that now and then it may be right to disregard an unfavourable balance of contra-indications and to operate when relief of the patient's distress can be given in no other way.

A Special Hospital Unit

Pulmonary tuberculosis is best treated in a sanatorium, and skeletal

tuberculosis is best treated in an orthopaedic hospital where the surgeon and his resident staff devote their whole time to the study and care of the locomotor system and where constant practice makes the nurses capable of ensuring the comfortable effective and long-continued immobilization of say, a hip or a spine on a frame or in plaster

But what is to be done when active pulmonary and skeletal lesions coexist? Unfortunately the regulations of the Ministry of Health on account of the danger of infection exclude these cases from the orthopaedic hospital, where the sanatorium physician and the thoracic surgeon would have been welcome In the sanatorium the residents and nurses ordinarily lack the technical knowledge of orthopaedics necessary to avoid displacement discomfort and pressure sores (often distressing and sometimes disastrous) when faced with the care of patients in large plasters or on unfamiliar frames It is easy to say that these cases can be effectively looked after in a sanatorium with the help of orthopaedic consultants but a good many of them need frequent skilled attention such as can only be given by experienced orthopaedic residents and nurses and a few can only be restored to health and activity by almost constant expert skill and care

Clearly there should be some unit set apart for this work in every region. Agreement will soon be reached as to the most suitable place which should be convenient for all concerned Where the unit is part of or attached to a sanatorium the residents and nurses must not be learners here to-day and gone to-morrow but experts who have chosen this service and mastered its technique They are then able to give their patients comfort and confidence through a time which is always difficult and can be very distressing

APPENDIX

SPLINTS AND APPLIANCES IN COMMON USE

In the treatment of bone and joint tuberculosis a thorough knowledge of the necessary appliances and how they should be used to best advantage is essential for their faulty use may produce deformities which will continue to distress the patient long after the original disease is soundly healed. While there are many different appliances, and even more modifications, the authors have felt it wise to describe and recommend only those which in their own experience have proved efficient. They may be made of plaster of Paris, various plastics, metal, or metal and leather combined; and each has its advantages.

SPLINTS AND APPLIANCES

PLASTER OF PARIS

This medium has great virtues, but these are matched by dangers which call for experience, craftsmanship, and care. It is pleasant to use and perfectly docile; when the plaster is in good order a flexible creamy fabric becomes a rigid shell in a few minutes, passing progressively from almost perfect pliability to rigidity at a rate which conforms favourably with the purpose and processes of the craftsman. With good team work little time is wasted and no movement need be hurried. A trained team of sister, nurses, and orderlies is essential. The best way of organizing an efficient service is to find an expert orthopaedic after-care sister and get her to train a team. If no such person is obtainable it is wise to send a carefully chosen sister to an orthopaedic hospital for training in the plaster room. She should be picked for her ability, good hands, and mechanical sense.

Materials and instruments (Fig. 161, as from the *Lancet*)

The instruments commonly used include several plaster-cutters, a saw, a much magnified glove-stretcher for opening the plasters after cutting, benders (useful in all sorts of ways), scissor-like cutters for soft plasters, strong scissors for cutting felt, strong scalpels, generally second hand from the theatre (not Bard Parker type), wire-cutters, indelible pencils, a tape-measure, a pint measure, pails, bowls, and a large bowl or a trough for soaking large fabric-plaques. It is assumed that a fracture-table is available.

The materials required are as follows

1. Plaster of Paris, known as superfine plaster.
2. Book muslin, 32 threads to the inch, stiffened with starch, not size.
3. Wool bandages.
4. White felt ¼ inch thick.
5. White adhesive felt ¼ inch thick, backed with zinc oxide.
6. Malleable iron wire 10–20 s.w.g.
   Flat strips of malleable iron 2 ft. long, ¾ inch wide, ⅛ inch thick.
8. Kramer wire 3¼ × 24 inches and 3¼ × 40 inches.

Furniture

A fracture-table, several strong, narrow deal tables, a suspension gallows, a bench with vice and hack-saw, pliers, wire-cutters, file, &c.

Though we know of no cases in which infection has been traced to the plaster the bandages should be prepared under conditions as free as possible from risk of contamination by pathogenic organisms. The felt is all autoclaved at 20 lb for 40 minutes, to eliminate the possibility of tetanus from a plaster-sore. Wool bandages which are *to be used over an operation wound are put with the other dressings in the dressing* drum for sterilisation The plaster and the plaster bandages are kept in air tight containers in a dry place.

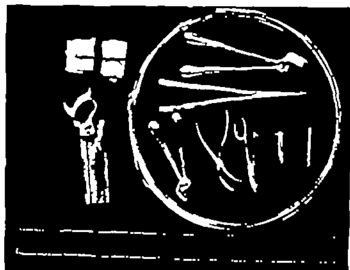


Fig 161.

Plaster bandage and bandage plaque

These can be home-made or purchased They can be applied as bandages or made into plaques; these will vary in width, length, and thickness to suit the occasion, but the thicker the plaque the less its docility

Making of bandages The muslin is supplied in rolls about 1 yard wide and 15 yards long This is torn into strips of various widths and lengths from 6 inches × 4 yards to 3 inches × 2 yards. From each strip of muslin the outer three threads on each side are drawn otherwise these threads tend to stray and hamper the application of the bandage The strips are then rolled loosely The process of changing the muslin strip into a plaster bandage is best learned by watching and practice The bandage is unrolled foot by foot and passed through a heap of dry powdered plaster on a smooth board and re-rolled as the plaster bandage. About 12–15 inches of the bandage lies exposed on the board at a time, and into it powdered plaster is rubbed. Just the right *amount of powder must be rubbed into and retained in the mesh or left as a* very thin even layer on the surface of the muslin as it is rolled up into the bandage. This rolling, too must be done rather loosely and very evenly If the bandage is too tight, water cannot soak into it if it is too loose the powder tends to escape before, during, and after the soaking and the bandage tends to run out in a tail during its application. *Plaques, sometimes called slabs can be made directly and kept folded up in tins.*

Soaking Everything must be ready beforehand A likely number of bandages should be set out on a tray; this is advisable because if bandages are picked out of the stock tin with a wet hand, drops of water get on to the other bandages and ruin them. Plenty of warm water should be set out in two deep basins for small plasters or two pails for larger ones. *A smooth board 36 × 24 inches should be handy for making plaques.*

When all is ready the first two bandages are gently lowered into the water and

there is a right way of soaking a plaster bandage It should be lowered gently to the bottom, in the horizontal position to avoid unnecessary loss of plaster powder and left undisturbed at the bottom of the pail until all bubbling has ceased It is then lifted clear of the water still in a horizontal position, and gently squeezed by a concertina like approximation of the two hands. This method avoids any unnecessary loss or disturbance of the plaster powder in the bandage If the bandage is lowered or lifted in a vertical position or handled carelessly powder is lost unevenly and the bandage is spoilt The squeezing is only meant to drive out the excess of water and the bandage should still be dripping wet The nurse unrolls 3 inches of the bandage and hands it to the surgeon in such a way that it comes naturally to hand

Application At this point it is well to remember that the characteristic virtue of plaster is the combination of great pliability while it is being applied with rigidity when it is fully set and that the period between these phases is critical It is necessary

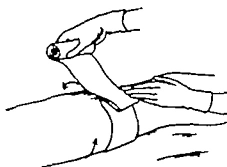


Fig 16 *a*.

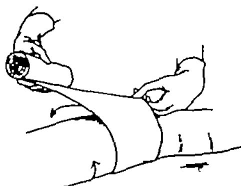


Fig 162 *b*.

to hold the limb exactly in the desired position before the plaster is applied and to maintain this position undisturbed during its application. If the position is altered after the application of the plaster or even of part of the thickness of the plaster unsuspected internal ridges will result which will be painful and liable to produce sores.

The comfort and safety of the patient depend on the even smoothness of the inner surface of the plaster and its accurate and comfortable fit round every bony prominence A plaster may be smooth and even on the outside and have a sharp ridge inside The position of a limb should never be altered during the application of a plaster If the position is wrong the plaster must be stripped off and re-applied.

One of two movements have been devised to ensure that each turn of bandage lies evenly and to allow changes in direction the loop by which a 2–3 inch loop of plaster bandage is thrown back and the run of the bandage redirected (Fig 162 *a* from the *Lancet*) or the draw by which one edge of the bandage is drawn a little back with the free hand while the run is directed (Fig 162 *b* from the *Lancet*) Purists use a loop or a draw on every turn of the bandage till the inner layer is complete This is particularly advisable in putting on the inner layer of a skin fitting plaster to ensure that there is no tiny ridge or unevenness caused by one edge of the bandage being pulled more firmly than the other If during the earlier stages of the application of the plaster a loop or a draw is applied as each turn covers a prominence and the plaster is well rubbed in and moulded to exaggerate if anything the hollows around the bone there is little fear of harmful pressure arising Plaster was regarded solely as a means of immobilizing bones and joints, but its value is now extended to the soft parts, the aim being to ensure an adequate hold everywhere without undue pressure anywhere In particular pressure is avoided over bony prominences. One should avoid letting the edge of a bandage run across a joint flexure e.g in front of the elbow at 90°

The foundation of a good plaster is a smoothly fitting inner surface; therefore too much care cannot be taken in the application of the first few layers. Once this has been done the motive of the application alters; the inner tube is complete, fitting the limb like a silk stocking and the outer structure can be put on quite differently with the sole purpose of adding strength where it is needed. The process is no longer bandaging in the ordinary sense, for there must now be no tension—the bandages are rapidly unrolled on the surface of the plaster for it is better not to lift the bandage from the surface lest any tension should be applied.

The inner tube can be left unsupported in certain places, e.g., the dorsum of the foot, the front of the elbow and the axilla. The upper two-thirds of the abdomen and the lower ribs in front need never be left enclosed in plaster The lumbar plaster is reinforced by broad (say 2 × 1 foot) plaques held in place by a turn or two of bandage round the upper abdomen; these turns of bandage can be cut in front and turned back to the sides before the plaster sets.

Making bandage-plaques from bandage A plaque 30 × 6 inches can be made from one or two bandages. Smaller plaques, made from smaller bandages, are used for the fore-arm and hand and broader ones to strengthen the plaster covering the back of the pelvis or the thorax Plaques are made by running the soaked plaster bandage to and fro on a smooth board; the bandage is run naturally on the board in one direction, then lifted and unrolled by the fingers as it passes back, dropped down and run, lifted and unrolled and so on. The whole process is immensely quickened if an assistant puts an index finger on each corner of the plaque as the lifting and withdrawal of the bandage are carried out

Application of the plaque The plaque is laid slack on the surface and rubbed on to it, being held in place by a bandage where necessary It can be left flat or gathered into round ropes or oval bars to form trabeculae The surgeon tries to copy the osteoblast and to place his trabeculae exactly where they will be needed, but he must apply intelligent anticipation, because his plaster buttresses cannot thicken or adapt them selves in response to stress or strain. Buttressing is necessary for instance both in front and behind the hip in a long spica.

Polishing A veneer can be applied to any dry plaster by polishing it with thin plaster cream with a wet hand This entails dipping the hand many times alternately in the cream and in water—in the cream to fetch it and distribute it over the area to be polished then in water because the polishing can only be done with a freshly wet hand Polishing can be carried out any time later than twenty four hours after the completion of the plaster

Patching When the plaster later on requires reinforcement it is patched with bandages or with bandage plaques; but a patch will not adhere to a dry plaster unless it is pasted on The process is as follows: the part to be patched and an area round are scratched and roughened with a saw or a rasp; some thinnish plaster cream, to form the paste is poured on or rubbed into the roughened area, bandages or plaques are then immediately applied

Skin fitting or padded plasters

For some purposes skin fitting plasters are best with padding here and there for special points, and perhaps a linear strip of wool to facilitate a vertical division of the plaster The plaster can be applied more delicately to the skin with the fold or draw in every turn, and it will fit the surface more smoothly The back of the pelvis and the lumbar spine should be covered with an even layer of felt and other prominent bony points should be given local protection. On the other hand there is a smaller margin of safety and any error in technique may be disastrous. In general therefore it is wiser to apply an even protection of wool-bandage or split white felt. When padding is used the first few turns of bandage have to be pulled firmly or the plaster will be loose and

its inner surface uneven. The pull of the bandage tends to rotate the part unless its movement is prevented by the use of one free hand; and this point should never be neglected where the exact retention of position is essential. For the thorax and pelvis two vests form a suitable protection; and a manœuvre is available by which the inner vest can be changed from time to time

Windows and bridges

Sometimes access to a wound or bony prominence is desirable This is achieved by leaving the inner tube unsupported locally and by framing the window with plaques or ropes. Flying buttresses are occasionally needed where an extensive window has to be cut Sometimes large areas of a limb, or even its whole circumference may have to remain uncovered or be uncovered periodically

Bridges are made with ropes of plaster or with ferro-plaster i.e plaster with a length of malleabl iron within it Ferro-plaster is easier to apply but it may be a nuisance because the buttress cannot so easily be modified or rearranged It is therefore often better to use plain ropes of plaster bandage The bridges are not begun until the inner skin of plaster has been put on and strengthened with a plaque or two but before this strengthening it is as well to outline the area of the window with an indelible pencil then the plaster round this area is strengthened with a few plaques and the rope bridges are applied The windows are better left undisturbed until the first exposure is required but their outlines can be cut with a sharp scalpel right down to the dressings or padding (in a window area the skin is always protected)

Traction or skeletal fixation

A combination of plaster and traction is sometimes invaluable Thorough plaster control of the proximal part provides a solid basis for an extension bow which may vary from the whole length of a Thomas splint to a small loop of wire providing traction for a finger So too can plaster provide a rigid hold for a Steinmann pin or for Kirschner wire.

Special plasters

Thoraco-brachial plasters should always take origin from a close hold of the pelvis, with the crest of the ilium protected by felt. The angle of abduction varies with the indications. When ankylosis of the shoulder is due to take place a position is chosen such that when the elbow is flexed the tips of the fingers come to the mouth The ulnar border of the hand should be supported or the hand will droop over the edge of the plaster when the patient is erect It is often wise to add a short extension of plaster rounded into the palm with the effect of a short cock up

Hip spica. The spica is applied on a fracture-table, with a fairly small pelvic support. Three or four minutes after its completion the patient should be lifted from the supine position on the table to a prone position on a layer of pillows on his bed in order that the back of the plaster may be looked over and any unevenness left by the support corrected Fingers are passed as far as possible between plaster and skin, to make sure of an even deep surface and sufficient plaster is removed in the form of an inverted U to allow for clean nursing' While the patient is in this position one should be sure that there is adequate strength between the back of the thigh and the back of the pelvis, and reinforcement can be added if necessary for this region is subjected to a concentration of stress and strain in front and behind. Extra strength is supplied behind by several plaques running obliquely from the back and sides of the pelvis down the thigh. In front the strength should be further increased by using bat wing plaques with a raised ridge at the point of strain.

Lower limb When the whole limb is included in the spica the plaster should be cut almost completely over the dorsum of the foot but extend beyond the toes on the

plantar surface: the toes are supported straight to favour the posture and exercise of the intrinsic muscles. There are ever present dangers of pressure sores, and a peripheral nerve can be paralysed by local pressure

Any long plaster is relatively strong where the strain is great but tapers down the limb But the nurses have to be reminded over and over again that they *must never lift the plaster by the lower end*

Fig 163 from the *Lancet*, shows a long spica plaster with the big window Note the flying buttress, and that there is plenty of room between it and the upper ribs and sternum. The rounded pre-sternal bar is made from plaques springing from a broad flat held on the lumbar side of the plaster During its application someone is moulding it and keeping it lifted from contact with the body



Fig 163

Plaster beds The patient lies prone on blankets and pillows on a firm narrow table. The soft pillows are so arranged that the patient's trunk is supported in the chosen posture. It is, for instance, of the utmost importance to avoid lordosis if any operation is to be done in the dorso-lumbar lumbar or lumbo-sacral region Any such lordosis means that after the operation the area of the wound is exposed to extreme pressure which is both painful and dangerous, and can only be mollified by so much padding as to destroy the control and comfort of the bed Therefore, before the bed is started pillows are adjusted under the patient's abdomen until exactly the right posture is obtained The authors prefer a padded plaster bed and their next step is to place a smooth sheet of gamgee or some such material on the body After this the plaster is applied either in sheets of fabric soaked in cream or by the progressive application of many plaques. It is best to apply several relative thin layers of fabric because each in turn can be moulded easily and without creasing to the varying curves of body and limb To ensure strength without waste of plaster two long malleable iron bars, accurately curved to fit can be incorporated, or the shell can be carried on the chassis of a Robert Jones frame (Fig 164) In addition it must be raised, by some means, a few inches above the mattress to allow nursing without lifting Alternatively both strength and position can be supplied to the shell by a skeleton wooden frame specially made to fit which carries it at the right height: but this requires skilled carpentry (Fig 165).

Assurance of good circulation

The greatest danger is that of *a general compression of a limb sufficient to impair or abolish circulation.* Compression complete and not quickly relieved causes gangrene; compression less complete may provoke ischaemic contracture or lead to a prolonged disturbance of the sympathetic control associated with oedema, stiffness and extreme osteoporosis. Compression almost always arises from subsequent swelling of the limb within the shell It is most desirable that compression should never be allowed to

develop, and absolutely essential that it should be immediately relieved. When a plaster is put on immediately after a fracture or an operation, it is often wise to split it vertically from end to end; it is indeed good policy to make this a standing order after operations anywhere distal to elbow and knee. It is good practice with skin fitting

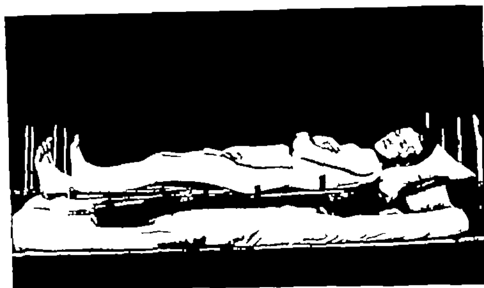


FIG 164 Patient on plaster bed which is resting on a Jones frame

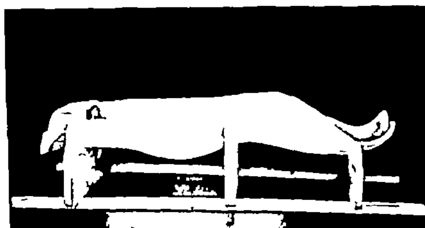


FIG 165. Plaster bed on a wooden frame to which it is firmly screwed.

plaster to put a folded woolly bandage vertically along the limb in the line on which this cut will be made then, when the plaster is just set but not yet rigid to make with a sharp scalpel two parallel cuts in the plaster about ½ inch apart down to the woollen bandage. The intervening strip is then completely cut out; short strips of bandage are tied round the plaster at two or three levels with a bow thus the nurse can easily loosen the tie to allow of further expansion if necessary. Later the plaster edges can be brought closer together if the limb shrinks inside the plaster. If necessary a further strip of plaster can easily be removed.

Points in nursing

Position When the patient is put back into bed difficulties arise unless the ward staff is well trained in certain points. First, the lower limb must always be so well supported that no pressure ever reaches the plaster over the tendo Achillis or the heel as a rule a pillow under the limb with nothing under the heel, is all that is needed, but it is a good plan to take a fracture-board from the lower end of the bed and put it as a second layer to raise the mattress under the knees.

Secondly if the patient is in a spica plaster a common mistake is to pack up his head and shoulders so that his chest or abdomen is forced against the upper rim of the

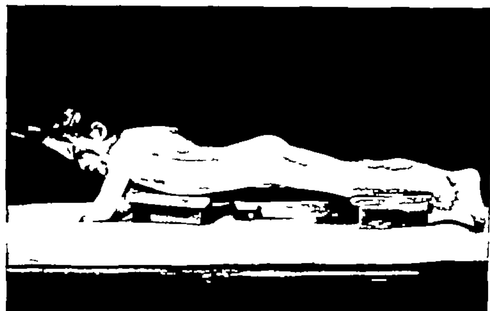


FIG 166 Patient on a turning case. Note the head piece of two parallel bars with bandage sling between the two to support the head.

plaster with very unpleasant results. The pillows should be so arranged that the body lies evenly supported on the plaster and on pillows just above it. With the patient lying in bed there should always be room for the whole hand to be inserted between the front of the body and the plaster

Drying A plaster sets in a few minutes but needs twenty four hours to dry If the plaster is exposed during this period or covered only with a porous blanket its sweating is imperceptible and all is well but if the plaster is covered up with a sheet &c. in bed it will be softened and ruined No amount of heating and drying during the first two or three hours after its application can eliminate the need for this precaution.

Plaster-sores Sores are almost unknown with good plaster work and quite unknown if a good plaster is followed by good nursing A patient in a big plaster can almost always be turned from side to side if need be right over on his face; on such points a ward sister will be given directions by the surgeon. A fairly frequent change of position may be necessary to relieve the discomfort of a very thin patient a patient who is tender or one whose skin is poor from age or illness.

The warning signs of a sore are often far from obvious and may be present for only a brief period First the skin becomes reddened over the point of pressure and this is the phase which is almost always associated with pain, though at times the patient will not mention it or may not even notice it during the hours of the day At night however

his nurse will observe a change from quiet to restlessness. Commonly a probationer has the best opportunity of observing her patients from night to night and therefore it is a primary essential for the junior nursing staff to be taught the importance of the least nocturnal restlessness of any patient in plaster to note it and to underline it in the night report This may be the only warning of a plaster-sore and the information should always be passed on to the surgeon so that he may have the opportunity of intervening

The second phase within the plaster is necrosis of the skin with loss of the sensitive nerve endings, thus the patient becomes more comfortable (cf gangrenous appendix)

The third phase is the deepening necrosis of the underlying tissues. By this time some discomfort will again arise and a characteristic smell may be noticed

The development of plaster-sores can only be prevented by the proper collaboration of the surgeon and the nurses. It is the duty of the surgeon to make his plasters comfortable to arrange with his nursing staff that the patient be given suitably frequent changes of position, and to make sure that watch is kept for any localized discomfort or any nocturnal restlessness, and that any such warning symptom is immediately reported to his resident or himself

Other materials

Plastic splintage. Bituminous felt in various forms has been used While these materials are light and fairly easy to apply they have been abandoned because they are clumsy and do not maintain accurate control. The plastic in most common use for many years has been celluloid which is durable and light, but non porous and inflammable These disadvantages can be overcome to some extent; the first by multiple perforations, the second by adding calcium chloride to the solution. But its very durability will prove a disadvantage if a child is allowed to wear a splint which no longer fits, because it is not worn-out. Splints have also been made out of the various acrylic resins now available; but these have the disadvantage of being non porous and difficult to make; they are suitable for small splints, such as for the wrist They are durable and unaffected by water

Metal and leather splints These splints are, without doubt, among the most useful, but they too have their disadvantages. The metal component should be easily worked, strong, rigid and light: but the perfect alloy is still being sought.

H. O Thomas was the originator of much of our modern splinting it has been said that Thomas made the splints and Robert Jones made them comfortable This he accomplished by the addition of padding covered with soft basil leather and this is now the standard practice for the rings of calipers and the saddles of frames: this leather has the great advantage of being soft, smooth, and easy on the skin.

Block-leather splints For these splints a bark tanned cow-hide about ⅛ inch thick is used. A plaster cast of the part is prepared and prominent bony points or ridges are exaggerated by plaster or felt. When this cast is dry the leather (which has been made sufficiently wet to be pliable) is applied, smooth side out moulded and worked accurately into place, then fixed there till it is dry It can then be removed and tried on in the rough. When size and fit have been approved it is fitted with duralumin stiffeners and lined with wash leather then straps (or lacing) are attached, and the appliance is complete This form of splintage is excellent for jackets, and sometimes useful for the elbow knee ankle wrist, or neck.

SURGICAL APPLIANCES

Appliances used in the treatment of spinal disease

1 *For use in recumbency* The Robert Jones straight frame (Fig 167) consists of two vertical bars joined by four transverse ones These bars are made of black iron in three sizes—1¼ × ⅜ inch 1 × ¼ inch and ¾ × ¼ inch. The weight of material used varies in

proportion to the size of the frame but it is essential that no sagging should occur when the frame is supported on blocks.

The transverse bars, from above downwards, are the nipple bar loin bar pelvic bar and abduction bar The nipple and pelvic bars partly encircle the patient s body These bars can hinge outwards, to facilitate examination of the patient being ordinarily kept in place by ¼ inch wing nuts. This is an Oxford innovation to eliminate the frequent

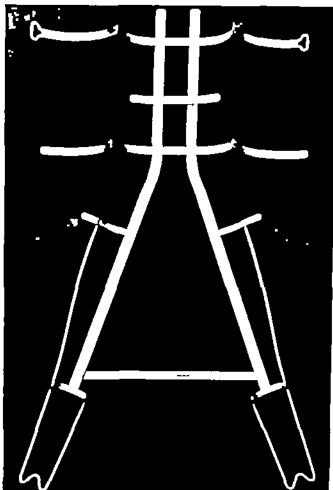


Fig 16 Jones spinal frame with the nipple and pelvic bars hinged back.

wringing of the bars to and fro which ends in their fracture The loin bar another Oxford innovation, lies between the other two and is designed to push up each side of the saddle in the waist and thus give greater comfort and support The transverse abduction bar stabilises the legs of the frame These are made of two rigid bars continuous with the vertical bars of the body part being kinked forwards just below the buttocks to allow for the different level of the thighs. At the lower end of these bars there are the malleolar bars, to which are attached extension bows. Angled out from the main bars are the knock-knee bars as shown in the illustration.

In high spinal disease a head piece can be attached at the upper end This is a metal hoop across which is stretched basil leather to support the head this may be straight



Fig 168 *a*.



Fig 168 *b*

Figs. 168 *a* and *b*. Head piece with temporal pads which are adjustable. Suitable for immobilization of head and neck.

or sunken according to the degree of extension required and to it may be attached apparatus to immobilize the head, an example of which is shown in Figs. 168 a and b.

To make the frame comfortable a saddle faced with basil leather and stuffed with horsehair is laid on it (Fig 169) This is tied to the frame with blind-cord: when these ties are loosened the saddle can readily be slid up or down on the frame to ensure an exact adjustment

The body of the saddle extends from the seventh cervical spine to the tip of the coccyx

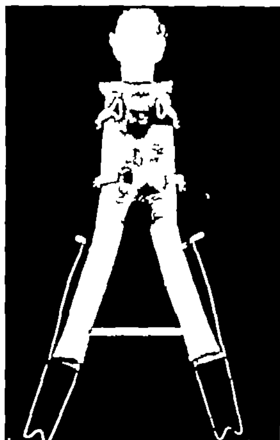


FIG 169. Saddle in position on spinal frame.

where it divides into two legs. As originally described the legs of the saddle extended only to the head of the fibula, the malleolar bars being separately padded The purpose of this was to allow the hip to be extended and the knees slightly flexed while at the same time the upper end of the tibia is gently supported without pressure on the calf muscles. It is often however more convenient to continue the saddle down to the malleolar bars and place a piece of firm padding behind the upper end of the tibia. The position of this padding is of great importance particularly in children. If the lower end of the femur is supported there is a continual tendency for the tibia to subluxate backwards on the femur and sometimes backward bowing of the tibia may occur at the upper tibial epiphysis.

There is always a tendency for legs held in abduction to adduct If the abduction is maintained purely by fixation below the knees a continuous strain is thrown on the ligaments and joint which is sure to result in a knock knee deformity It is of the greatest importance therefore that the abduction must be maintained by bandaging

the whol limb *but particularly the thigh* to th knock knee bar which must be angled well away from the limb, and thi bandaging must be done in such a way as to maintain the limb in neutral rotation (Fig 1 0)

During the early stages of th disease the legs shoul l be kept immobilized, but throughout this time it is most important that the feet and ankles be kept mobil and

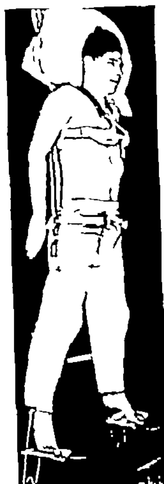


Fig 1 0 P tient on spinal frame Both thighs ban daged to knock knee bar

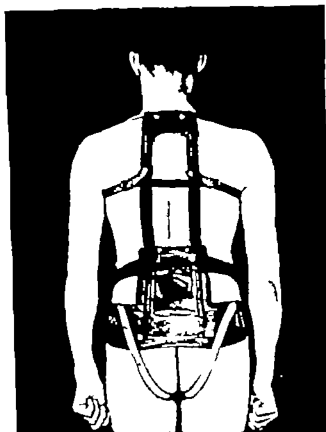


Fig. 171 Robert Jones type of spinal brace

free from deformity by exercises. The frame has certain advantages in that it is com fortable maintains adequate immobilization, exposes the maximum of skin to the air and makes nursing as simple as possible But frames have their limitations, they are unsuitable for very obese patients and cannot comfortably accommodate a severe kyphos, although a moderate kyphos can be fitted into a hollow in the saddle In these cases, and where there is lateral deviation, a plaster bed is better Just as much care in the prevention of deformity of the limbs is required in nursing a patient on a plaster bed as on a frame and whatever the appliance used, great care must be taken of the skin wherever there is any pressure particularly the skin of the back over the sacrum, which must be treated whenever the patient is turned. Groin straps require great care

and frequent attention. They are not intended to carry much counter traction. The extensions on the well limb need never be pulled down tight and the affected limb is to be immobilized by fixed extension rather than continuous traction The skin under the groin straps must be changed very frequently and kept well washed dried, and lathered

2. *Appliances for use in ambulation.* Even when spinal disease has become quiescent it is unwise to get the patient up without the protection of some form of brace for at

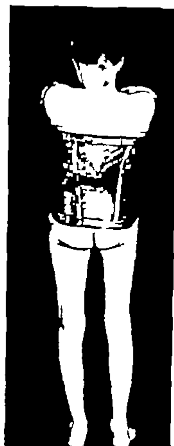


Fig 172. Block leather jacket to control lateral angulation.

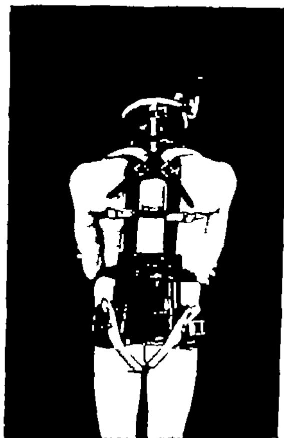


Fig 173. Block leather collar attached to brace.

least a year whether or not it has been grafted. The nature of the brace must depend to a certain extent on the level of the lesion.

(a) For disease between mid-dorsal and mid lumbar spine the Robert Jones brace (Fig 171) is the most satisfactory It consists of a rigid metal frame covered with leather and moulded to the shape of the spine It extends from the seventh cervical spine to the lower end of the sacrum. It is held closely fitting into the lumbar region by a waist band and a second strap passing round to the front between the iliac crests and the great trochanters. Both straps are jointed in front to an abdominal section. Th brace is held down by groin straps covered with soft basil leather The upper part of the brace is bent so that at the top it stands away from the spine by two fingers breadth the shoulders being braced back by shoulder straps similar to the groin straps The efficacy of the Jones brace depends upon the activity and strength of the erector spinae The shoulder straps must be regarded as reminders rather than supports. No one should be allowed up until his dorsal muscles are well reconditioned; even so periods of rest in

recumbency are advisable during the day While this brace can be made from measurements, it is usually better to make it from a dorsal plaque plaster cast particularly if the deformity is severe This brace will control a simple kyphos but has little or no control over lateral angulation, which therefore requires a block leather jacket (Fig 172) This can be fitted with shoulder straps

(b) For disease of the upper spine a collar can be added (Fig 173) to the brace which is attached to it by straps. This is particularly useful for children with high dorsal



Fig 174 Block leather collar

disease. For disease of the cervical spine requiring less support a block leather collar reinforced with aluminium strips is adequate (Fig 174).

(c) When the disease involves the lower lumbar and lumbo-sacral parts of the spine a lumbar corset of block leather is the usual form of immobilisation (Fig 175) In the early stages this may not give enough support and a short jacket spica including one leg to the knee may be required.

Appliances for disease of the hip joint

1 *The Robert Jones Frame* (Figs. 176 *a* and *b*)

The hip frame is similar to the spinal frame except that it is so made that either one or both legs can be abducted to the desired angle Immobilisation of the hip is ensured by adhesive strapping extensions applied to the whole limb on each side then tied to the extension bows. Counter traction is obtained by means of a groin strap on the unaffected side Fig 176 c shows a patient with tuberculosis of the right hip on a Jones frame Note the swelling which is an abscess, on the antero-lateral aspect of the thigh.

2 *Hip spica* (see section on plaster of Paris).

3 *Walking-spica* When the disease is sufficiently well healed to allow weight bearing a short spica with below knee flexion piece slotted into the heel of the shoe is useful as it permits flexion of the knee while the hip is protected against strain (Fig 17)

Appliances for disease of the knee joint

1 *Recumbent* Apart from plaster of Paris most appliances for treatment of tuberculosis of the knee are based on the original Thomas splint or calliper What modifications there are are usually in the shape of the ring; none of them is better than the original and few are as good.

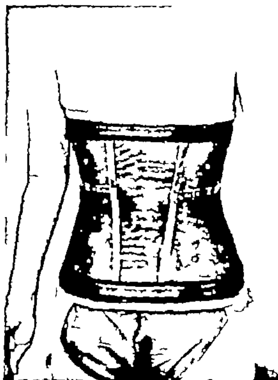


Fig. 175 Block leather corset

The Thomas splint consists of a ring slightly elliptical in shape padded and covered with soft basil leather and, welded to the ring just in front of its longest diameter are two side bars which are continued down the side of the leg to extend about 12 inches beyond the foot to form an extension bow The ring is made to be a snug fit round the top of th thigh the counter traction being taken on the tuber ischii, the outer part of the ring fitting snugly below the greater trochanter

The leg lies between the side bars with strapping extensions from the knee with the wicks tied to the bow in the usual way The leg rests in a bivalved plaster cylinder supported by slings extending across between the lateral bars. The apparatus should be raised from the bed by 0 inches and this can be done either by slinging the splint from a beam or lse by fixing a metal stand to the end of the splint which acts both to elevate the splint and maintain dorsiflexion of the foot

In this apparatus nursing is easy The patient is reasonably mobile in bed the skin can be exposed to the air and the knee can be examined by removing the anterior half of the bivalved plaster cylinder without interfering with its immobilization.

If it is decided to treat the knee without traction in the acute stage nothing short of a plaster hip spica will suffice A large window should be cut over the knee to allow inspection.

Whatever method is used care must be taken that the knee is flexed at about 10–15

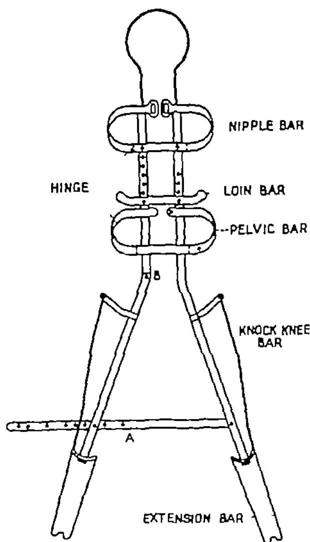


Fig 170*a* Diagram of hip frame and its component parts.

and that the upper end of the tibia is supported. If this is not done, there is always a risk of subluxation.

2. *Ambulation*—the Thomas caliper (Fig 178) or Thomas walking-splint (Fig 181) The upper part of the caliper is exactly like that of the bed-splint, but each bar ends in an attachment which fits into a tube in the heel of the shoe The side bars are held together by a strap passing round them and the leg just above the ankle and the knee is held by a sling For a time it is best to have a knee-guarding plaster as well (Fig 179) The caliper is meant to carry the weight of the body from the heel of the shoe to the

tuber ischii so that none is transmitted through the knee Therefore the side bars can be lengthened or shortened at will by a sliding attachment held by two screws. This is particularly necessary in children whose growth necessitates frequent adjustments in length As the weight is taken on the tuber ischii it is obvious that the size and shape of the ring is of great importance The tuber ischii lies about 1½ inches behind the line of the hip joint and thus 1½ inches behind the direct line of thrust, which is up the shaft of the femur The tuber ischii, as the centre of weight bearing will always try to find

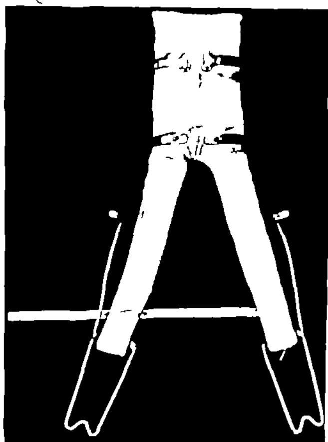


Fig 1 6 b Hip frame and saddle Note method of abducting one hip. Frame can be made to abduct either or both hips.

the lowest part of the ring As the side bars should correspond to the shaft of the femur in weight bearing it follows that they should lie 1½ inches in front of the tuber ischii, but if the lowest point of the ring is immediately over the inner bar there will be a marked tendency to internal rotation, resulting in an unwieldly gait, with intoeing It is important therefore that the ring should be flattened for about 2 inches behind the inner bar to overcome this tendency (Fig 178 b)

Appliances for disease of the ankle and foot

During active disease of the ankle the best form of immobilization is the full-length plaster No short plaster can give protection from rotation strains. When the disease

is quiescent and weight bearing is possible the ankle may be controlled with a double iron with flat heel socket and rigid metal sole plate (Figs. 180 a and b). Or when weight bearing must be avoided a Thomas patten-ended calliper (Fig 181) can be used with a patten on the other shoe

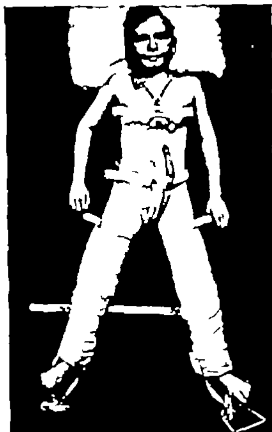


Fig 1 6 c Patient with tubercular right hip on frame

Splints for the upper limb

The shoulder and elbow No mechanical appliance will give adequate immobilization to a shoulder or elbow in the acute stage and a thoraco-brachial plaster should always be used. This is dealt with in the section on plaster of Paris. When quiescence has been reached, the elbow can be immobilized in a splint either plaster or block leather extending from the axilla to the wrist or knuckles, depending on whether or not the superior radio-ulnar joint is involved

The wrist Plaster is most satisfactory in the early stages, but this may ultimately be replaced by a moulded block leather when the disease is quiescent (Fig 18*)

Care of Appliances

No description of appliances would be complete without some mention of the care and attention required to maintain their efficiency and comfort, and a wholesome condition of the skin with which they are in contact All appliances in use should be checked by a competent person at suitably frequent and regular intervals both as regards their

1. 177 Short hip spica with knee flexion piece attachment.

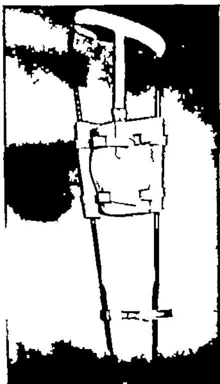


Fig. 178 a. Thomas's knee calliper



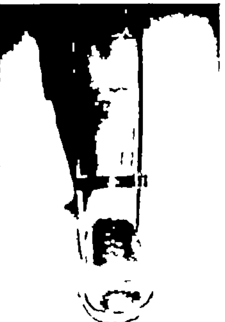
Fig 178 b Ring of caliper showing flattening of Ischial bearing area.



179 Thoma al per and knee gua ling plast



Fi 180a



Fi 180b

Fi 180 a and b Do le iron with flat s k t in heel f hoe

condition and their accurate and comfortable fit. The patient's skin should be examined at all pressure points for evidence of any undue compression or friction.

Before he goes home the patient must be taught how to take proper care of his splints. The importance of cleanliness of both patient and splint cannot be over-emphasized All leather parts of the splint in contact with the skin must be washed at frequent

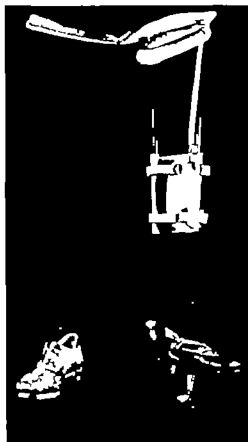


FIG 181 Thomas's patten ended caliper with patten on other shoe For disease of the knee it is worn with a knee guarding plaster and for disease of the ankle the shoe is replaced by a below knee plaster

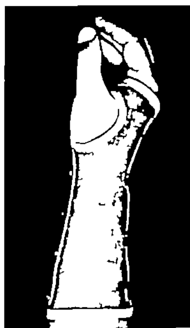


FIG 182. Block leather splint for disease of the wrist.

intervals with soft soap and water; when the leather has been washed and dried some soap lather should be rubbed into it to keep it soft. The skin in contact with it must be treated in an exactly similar manner Under no circumstances must spirit be applied to either skin or leather since it promotes the formation of cracks and sores.

MEASUREMENTS REQUIRED BY INSTRUMENT MAKERS

Although individual splint makers vary in detail in the measurements they require for making splints and appliances, the following is a rough guide which should be of assistance in most circumstances.

Robert Jones Frames

Patient lying with arms loosely by his sides:

Measurements:

1. From the nipple line to the gluteal fold
2. From the gluteal fold to 1½ inches above the malleoli (1 inch in children)
3. Circumference at nipple line in full inspiration.
4. Circumference of pelvis at level of anterior superior iliac spines
5. If a head piece is required measure from nipple line to the crown of the head

It is unnecessary to take special measurements for the saddle as it will be made in proportion to the frame

Moulded leather Jackets

These can only be made from a plaster mould of the patient. A cast is made by applying a thin layer of plaster bandages immediately on to the skin, without padding except for a piece of plaster wool folded on itself which is placed on one side and extends from top to bottom of the cast. When the plaster has set, i.e. in about ten minutes, the cast is split by cutting down on to the wool strip with a sharp knife. The split is gently opened up and the plaster removed; the split is at once closed with encircling bandages, any deformity which has occurred in the process being corrected by further encircling plaster bandages.

When the plaster is dry and hard the lower end is closed with plaster bandages. The inside of the cast—greased to prevent sticking—is then filled with plaster paste of an even creamy consistency, a wooden pole being placed in the centre to facilitate subsequent handling. When the plaster is hard the outer negative case is removed leaving the positive case in its rough state. This is scraped all over to make it smooth and to ensure an accurate fit when the leather mould has been made on it.

This procedure is necessary for all moulded leather splints whether used for the trunk, neck, or limbs.

Jones spinal brace

Where severe deformity is present a plaster cast must be taken either as for moulded leather jackets or by simply applying two or three plaster slabs to the back and allowing them to dry in position.

Where deformity is less, take a template of the back using a piece of malleable metal (strip aluminium ½ inch wide and ⅛ inch thick is a suitable material). Mould the metal carefully to the back in a line approximately 2 inches from the centre of the spine at the bottom to 1½ inches from the centre at the top. Mark the level of the tip of the coccyx at the bottom and the level of the shoulders at the top and trace the resultant model on a piece of paper.

Take the following measurements:

1. Circumference of the pelvis at the level of the anterior-superior iliac spines.
2. Distance between anterior superior iliac spines.

When taking the tracing be sure the patient is lying in a good line on a hard table with arms at sides and a small pillow beneath the chest.

Ring callipers

Measurement for the ring must be taken horizontally round the thigh directly beneath the ischial tuberosity. The length is measured from the tuberosity to the plantar surface of the heel.

Below knee irons

Measure length from neck of fibula to plantar surface of the heel and circumference of leg at neck of fibula.

Lovett's Table

Difference in inches between r. l. and apparent shortening	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
	Distance between anterior superior spines in inches.																	
¼	5	4	4	3	3	[illegible]	2	[illegible]	2	2	2	2	2	1	1	1	1	1
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	23	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	23	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	[illegible]	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼		40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½			39	34	30	27	24	22	21	19	18	17	16	13	14	13	12	11
2¾				38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3				42	35	32	29	27	25	23	22	21	19	16	18	16	14	13
3¼					39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½						40	35	33	30	28	26	24	23	22	21	19	17	16
3¾							38	33	32	30	28	26	25	23	22	20	18	17
4							42	38	35	32	30	28	26	23	23	21	19	18

Kingsley's Table

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0·5	1	6·5	16	12·5	31	18·5	50
1·0	[illegible]	7·0	17	13·0	33	19·0	[illegible]
1·5	3	7·5	19	13·5	34	19·5	54
2·0	4	8·0	20	14·0	36	20·0	56
2·5	6	8·5	21	14·5	37	20·5	58
3·0	7	9·0	22	15·0	39	21·0	60
3·5	9	9·5	24	15·5	40	21·5	63
4·0	10	10·0	25	16·0	42	22·0	67
4·5	11	10·5	27	16·5	43	22·5	70
5·0	[illegible]	11·0	28	17·0	45	23·0	75
5·5	14	11·5	29	17·5	47	23·5	80
6·0	15	12·0	30	18·0	48	24·0	90

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